

# FY98 HUMAN SYSTEMS TECHNOLOGY AREA PLAN



**HEADQUARTERS AIR FORCE MATERIAL COMMAND  
DIRECTORATE OF SCIENCE & TECHNOLOGY  
WRIGHT-PATTERSON AFB OH**

Approved for Public Release; Distribution is Unlimited

19980226 055

DTIC QUALITY INSPECTED 3

## INTERNET DOCUMENT INFORMATION FORM

**A . Report Title:** FY98 Space and Missiles Technology Area Plan

**B. DATE Report Downloaded From the Internet** 25 Feb 98

---

**C. Report's Point of Contact: (Name, Organization, Address, Office Symbol, & Ph #):** HQ AF Materiel Cmd, Wright Patterson AFB, OH

**D. Currently Applicable Classification Level:** Unclassified

**E. Distribution Statement A:** Approved for Public Release

**F. The foregoing information was compiled and provided by:**  
**DTIC-OCA, Initials:** PM **Preparation Date:** 25 Feb 98

---

The foregoing information should exactly correspond to the Title, Report Number, and the Date on the accompanying report document. If there are mismatches, or other questions, contact the above OCA Representative for resolution.

**Note:** This Technology Area Plan (TAP) is a planning document based on the President's FY98 Budget Request. It does not reflect the impact of the FY98 Congressional appropriations. You should consult AL/XP, DSN 240-2661 or Commercial (210) 536-2661 for specific impacts that the FY98 appropriation may have had with regard to the contents of this particular TAP. This document is current as of 1 June 1997.

About the cover.....



The cover picture depicts the role of Armstrong Laboratory as the provider of world-class human centered science and technology (S&T) in support of the Air Force S&T mission to discover, develop, and deliver affordable technology for global engagement. As the advocate of the human-in-the-loop, Armstrong Laboratory is the premier DoD organization for (1) improving the warfighters' capabilities to win and survive in today's changing combat arena, (2) enhancing the health and safety of Air Force people, (3) and preserving and protecting the environment.

# HUMAN SYSTEMS TECHNOLOGY

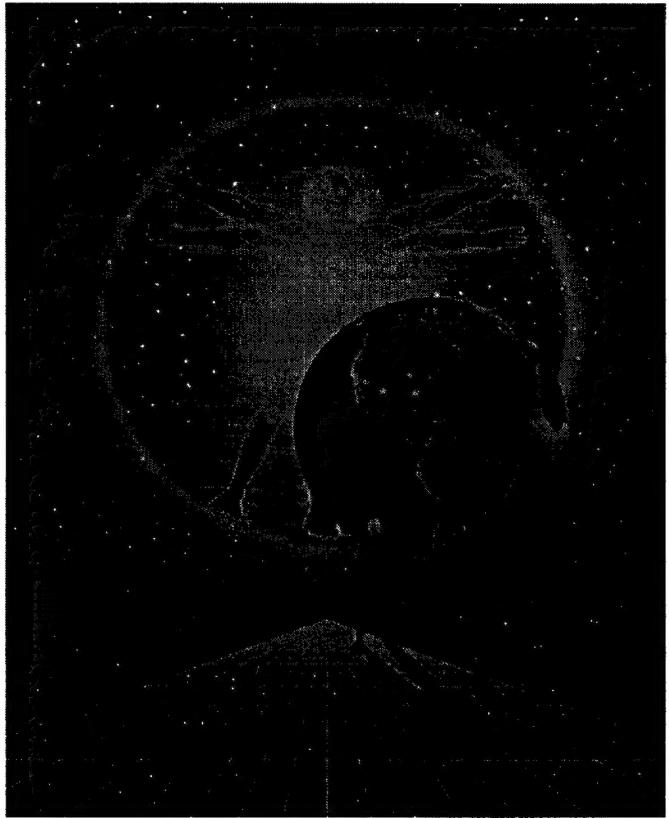
The Armstrong Laboratory is the Air Force laboratory uniquely positioned to engage a diverse and multi-disciplined technological arsenal to address the warfighter's human systems deficiencies. The capability of bringing to bear the full weight of physical, biological, biomedical, and behavioral sciences along with human factors engineering is now needed more than ever in the post Cold War era. Today, instead of facing a single massive threat, we are challenged with the potential for simultaneous multiple low intensity conflicts. Instead of a robust DoD budget, we are now faced with conducting both operations and acquisition in a fiscal climate that is highly resource constrained.

These factors have changed the face of today's Air Force from one with a focus on performance featuring new and large weapon systems having ever increasing speed, range, altitude, and firepower to a smaller force with fewer weapons systems, fewer flying hours, fewer people, less acquisition, and a focus on maintaining aging systems. This shift in the concept of operations places an unprecedented demand on Air Force people. It imposes great physical and cognitive demands because of more numerous and longer missions combined with reduced crew and support personnel. This makes people, as noted in the New World Vistas report, a more important Air Force asset than ever. Another outcome of this shift is the increasing importance placed on weapon system affordability. The Air Force must now very carefully manage the total-life-cycle costs of all weapon systems, current and future, to ensure a maximum return on investment for each of its acquisition and personnel dollars.

Armstrong Laboratory is uniquely positioned in the Air Force Science and Technology (S&T) structure to meet these challenges. Accordingly, Armstrong Laboratory's S&T portfolio of cutting-edge human systems technologies are being focused on such high leverage programs as:

- Human Factors Engineering for Uninhabited Aerial Vehicles
- Psychological Aspects of Information Warfare
- Virtual Reality Training and Mission Rehearsal
- Advanced Logistics Technologies for Affordable and Deployable Weapon and Support Systems
- Human Interactions with Complex Automated Systems
- Modeling of Human Performance
- Human Performance Enhancement
- Non-lethal Weapons Effectiveness and Safety
- Personnel Selection for Job Performance
- Health-Based Risk Assessment
- Environmental Compliance and Pollution Prevention

In the future, a smaller force will perform the Air Force combat mission - Global Reach, Global Power. To maintain a high degree of combat readiness and mission performance, the Air Force must place increasing emphasis on affordable and supportable "force multiplying" weapon systems and the retention and training of intelligent people for highly complex jobs. We must concentrate our technology programs to



exploit the underlying strengths of air and space power, i.e., speed, range, precision, lethality, and flexibility.

In the cockpit, 3-D visual and auditory displays will provide the pilot with an overall view of the surroundings, heightening situational awareness during air combat missions. These same technologies will give the battlefield commander faster information flow for improved command and control.

The entrance of women into fighter aircraft requires an assessment of cockpit designs and the development of improved protective equipment to better accommodate female anatomy and physiology.

Air Force recruits will receive basic job training from personal computer-based "intelligent tutors" to gain deeper job understanding.

The same technology will emulate one-on-one instruction from a knowledgeable teacher to enhance the quality of mathematics and science education in schools throughout the US.

Pilot candidates will be assigned to particular types of aircraft based on their physiological and psychological profiles as determined by physical exams and specially designed aptitude tests.

The emergence of numerous regional conflicts has shown that Air Force units can be deployed anywhere in the world on short notice, and must be prepared to fight continuously for weeks under self-supporting conditions.

The key to such capability includes weapon systems that are designed for deployment with maximum supportability under field conditions.

New job structuring methods will ensure that future Air Force jobs are designed and structured to meet specific Air Force and joint-Service missions. Advanced person-job match technology will ensure that the best people are rapidly identified and utilized in their most effective job to meet the deployed mission.

New techniques will enable personnel to overcome fatigue in sustained operations and maintain optimum performance for war.

New concepts in information warfare operations will allow the Air Force to achieve its military campaign objectives more quickly with less cost in both resources and lives.

The myriad of ground equipment associated with aircraft will be combined into one piece of multi-functional equipment. This will reduce the amount of equipment necessary for deployment. Exotic weapons, such as lasers, are already on the battlefield and the taboos against chemical and biological weapons could disappear if the tide of a future battle turns against an aggressor. The Air Force must be ready to fight and prevail in these types of hostile environments.

New life support equipment will protect personnel across the range of possible threats, including conventional and exotic weaponry. Mission adaptive protective ensembles will be designed to enhance mission accomplishment.

The Air Force will experience major funding reductions over the next decade, requiring subsequent decreases in

laboratory infrastructure and increases in cooperative research and development agreements with academia and industry to aid transfer of human centered technology to the private sector. Additionally, both industry and government will require health-based risk-assessment technologies to help protect and clean the environment.

Future Air Force systems will incorporate maintenance considerations early in the design to lower life cycle costs and make them more affordable.

Early environmental analysis will "design out" or mitigate health and safety hazards related to new materials and toxic chemicals prior to use in Air Force and commercial products.

High operational training costs will drive development of networked simulation to link all the services in a joint training and mission rehearsal environment that includes all functional aspects of operational and logistics support elements to ensure fully integrated and evaluated operational plans as well as increased force readiness at reduced cost.

The human will remain the most critical component of weapon systems well into the 21st century. Advances in human systems technology will ensure that Air Force personnel perform to the best of their ability throughout their careers.

BRENDAN B. GODFREY, SES, DAF  
Director  
Armstrong Laboratory

RICHARD R. PAUL  
Major General, USAF  
Technology Executive Officer

	Page
<b>VISIONS AND OPPORTUNITIES</b>	iii
<b>INTRODUCTION</b>	1
<b>MAJOR TECHNOLOGY THRUST 1:</b> Crew Systems	5
<b>MAJOR TECHNOLOGY THRUST 2:</b> Human Resources	10
<b>MAJOR TECHNOLOGY THRUST 3:</b> Aerospace Medicine	15
<b>MAJOR TECHNOLOGY THRUST 4:</b> Occupational and Environmental Health	18
<b>MAJOR TECHNOLOGY THRUST 5:</b> Environmental Quality	22
<b>GLOSSARY</b>	26
<b>INDEX</b>	28

Armstrong Laboratory is the only Air Force laboratory with a unique, synergistic mixture of Defense Health Program and Science and Technology resources addressing a wide range of Human Systems needs throughout the Air Force. Armstrong Laboratory is committed to enhancing human performance in Air Force weapons systems and in all occupations. The Human Systems technology programs, conducted at Armstrong Laboratory, provide a full spectrum of technology development to complement the other technology areas of the USAF Science and Technology (S&T) program (Figure 1).

Armstrong Laboratory personnel have consistently earned prestigious national and international science and technology awards. Recent Staff recognition includes the R&D 100 Award, the Defense Standardization Award, the Aerospace Medical Association H.G. Moseley Award (most outstanding contribution to flight safety), the Institute of Electrical and Electronic Engineers Distinguished Member Award, the Julian E. Ward Memorial Award (art and science of Aerospace Medicine during residency training), the Chairman of the Joint Chiefs of Staff Award for Excellence in Military Medicine, the Harold E. Brown Technology Transition Award for the past three years, Federal Laboratory Consortium Award for Excellence in Technology Transfer, and the Harold Metcalf Award (the top award given by the Federal Laboratory Consortium).

For many years Armstrong Laboratory has developed technology that extends the capability of the human being in wartime endeavors. As aircraft materials and designs have improved, the aircrew member has become the operational limiting factor in weapon systems operations. Laboratory scientists and engineers have worked successfully to extend pilot tolerance to high G-forces and high speed ejections.

Today's high performance aircraft are expensive, both in terms of initial purchase and life cycle costs. By developing computer-aided analytical tools for logistics, toxicology, and force management, Armstrong Laboratory has factored the human operator into the process early in systems design, and thereby greatly reduced the life cycle costs for tomorrow's systems.

Onboard computers provide a tremendous array of data to the human operator. Without the training and display technologies developed by the Armstrong Laboratory, raw information would overload not only pilots and weapons systems operators, but technicians as well. Through our display and analysis technologies, we've turned information into useful tools, extending the mission capabilities as well as human knowledge.

The addition of female pilots to high performance combat aircraft affected the requirements for protection, and we have embarked on programs to fulfill these additional needs.

At the forefront of emerging aerospace medicine technology, laboratory researchers have expanded the technology base so that revised physical standards could be adopted that extend the range of operational performance. In many cases, this research has kept experienced pilots, who might have previously been grounded, in the cockpit and extended the time their skills are available to the Air Force. This program evaluates approximately 300 aircrew per year (pilots, navigators, weapon system operators, etc) and returns over 80 percent to flying status. This is the equivalent of 11 squadrons of aviators that would otherwise be grounded for the entirety of their remaining military service. At an average training cost of \$1.5M per aviator, this represents a total cost avoidance of \$500M per year, which will be lost by elimination of this capability.

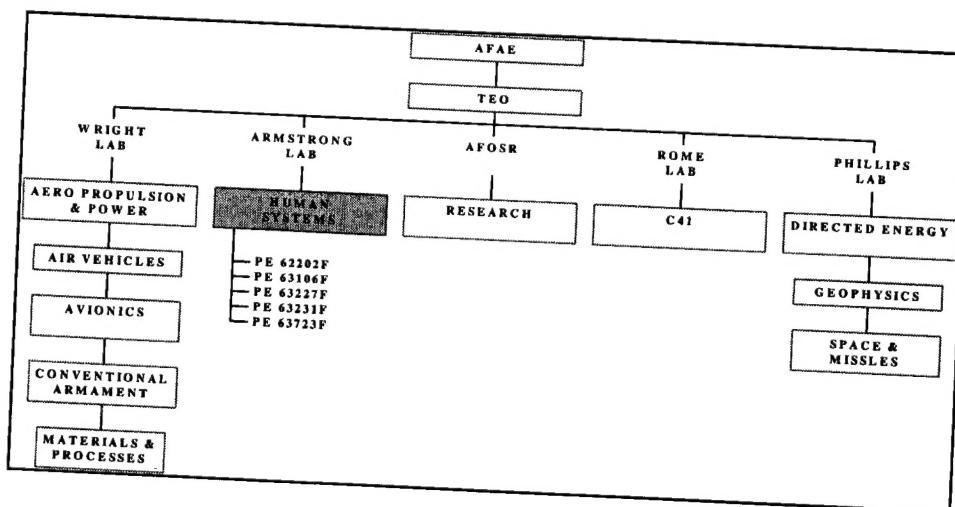


Figure 1. Air Force S&T Program Structure

The Armstrong Laboratory works closely with its customers to ensure that the products of research meet their needs and provide cost savings. One example of our commitment to the user is the Advanced Technology Anti-G Suit (ATAGS) developed to combat G-induced loss of consciousness in high performance aircraft. This new G-suit combines an abdominal pressure bladder with bladders that completely encircle the leg from the hip into the boot. The result is a 60 percent improvement in endurance over the present G-suit. When combined with the positive pressure breathing ensemble, COMBAT EDGE, ATAGS produces greater than a four-fold improvement in endurance. ATAGS has moved from Armstrong Laboratory to the Human Systems Program Office where it is being transitioned to ACC and AETC. Another example, the advanced on-board oxygen generating equipment developed by Armstrong Laboratory, decreases logistics requirements and is projected to save the USAF \$645M over 20 years.

The Air Force allocates almost 10 percent of its total S&T budget to Human Systems technology, as shown in Figure 2. (These and all funding figures reflect the FY98 President's Budget Request).

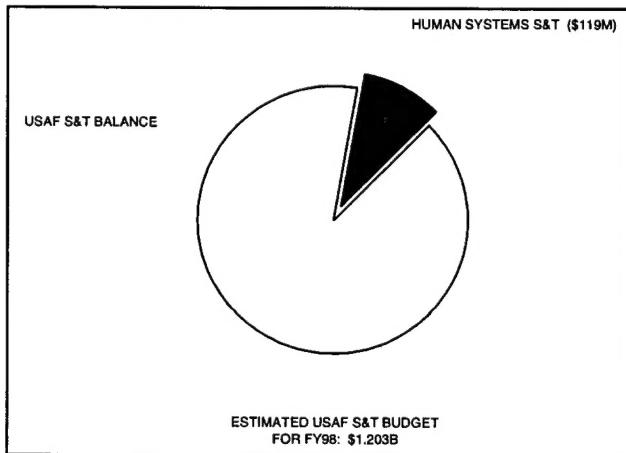


Figure 2. Human Systems S&T \$ VS USAF S&T \$

Armstrong Laboratory has five major technology thrusts, as listed in Figure 3, and each makes a unique contribution to improving warfighter capabilities and enhancing the operational performance of Air Force personnel. The laboratory distributes Air Force S&T resources among the five integrated thrusts as shown in Figure 4.

1. Crew Systems
2. Human Resources
3. Aerospace Medicine
4. Occupational and Environmental Health
5. Environmental Quality

Figure 3. Major Technology Thrusts

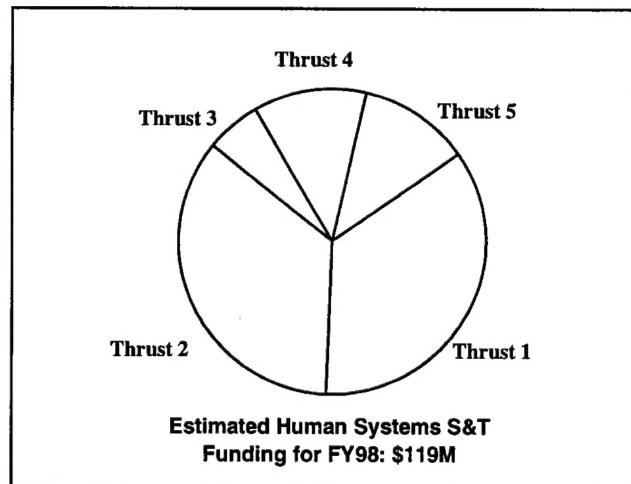


Figure 4. Major Technology Area \$

**THRUST 1, Crew Systems**, provides the design criteria to ensure that new weapon systems are compatible with human operator capabilities and requirements, and that air and ground crews are protected from physical hazards during air operations. This thrust emphasizes the development of advanced cockpit and display design tools to improve situational awareness and to reduce workload, laser visors for aircrew protection, new escape systems, and anti-G and altitude protective equipment. Products from this thrust transition to the warfighting commands. All of the commands have highly ranked this thrust.

**THRUST 2, Human Resources**, provides the technologies to assure that the quality of the Air Force's future work force is maintained through improved personnel selection, classification, training, and logistics systems technologies. It increases the effectiveness of combat operations through human-centered campaign planning, information warfare, and psychological operations, and enhances the operability, supportability, affordability and deployability of current and future weapon systems.

Emphases in this thrust are on application of artificial intelligence technologies to computer-based training, development of effective new technologies to improve aircrew training, development of technologies to accurately predict human responses to military operations, information flow, and psychological operations, tools which can be used to "design in" maintainability, increase deployment planning accuracy, and speed while reducing required airlift, reduce the costs of air logistics center (ALC) maintenance, and improve the readiness of supporting logistics elements. The research in the Human Resources thrust directly benefits all MAJCOMS and functional agencies. Many of the technologies transition through the Air Education and Training Command, Air Force Materiel Command, all operating Commands and Air Force Special Operations Command as well as the joint warfighting command campaign planning staffs. In many cases, industry weapon systems developers and manufacturers are users of these technology products.

**THRUST 3, Aerospace Medicine**, investigates the human biomedical factors affecting performance and awareness in the cockpit, and applies the results to the selection and retention of rated personnel.

Current topics include an improved ability to detect cardiovascular disease, the incidence and prevalence of neurologic and psychiatric disorders in crew members, and potential revisions to aeromedical regulations for aircrew vision standards including those for night vision. The aeromedical physical standards defined in this thrust are transitioned to the Air Force Surgeon General and to the operational commands.

**THRUST 4, Occupational and Environmental Health**, produces data used in setting standards and criteria for safeguarding Air Force personnel and the civilian community from occupational and environmental hazards associated with military systems and operations. Present emphasis is directed at toxicity of new products, biological effects of laser and radiofrequency radiation, and the impact of noise and sonic booms on humans, animals, and structures. This research supports Air Force compliance with environmental and occupational safety legislation and provides legally defensible data for countering lawsuits against the government.

**THRUST 5, Environmental Quality**, provides technologies that will keep our developing weapons systems abreast of evolving environmental regulations, ensure ongoing peacetime operations and training, and drastically cut the costs of cleanup, ownership, or base closure. Increasing regulatory restrictions on air and water quality challenge this technology area to identify and cost effectively abate adverse environmental impacts without degrading mission capability. Although this thrust emphasizes the assessment and management of risk, the end products are enhanced readiness and improved quality of life. Our primary customers include MAJCOMS and base commanders, their civil engineers, environmental managers, and planners.

mandatory site visits and investment plans have been replaced with cooperation between Air Force and industry research programs. Armstrong Laboratory is cooperating with industry to satisfy MAJCOM deficiencies. Along with the Air Education and Training Command, we sponsor an industry day to discuss future needs and begin the process of working with industry to address solutions to those needs. Major IR&D investments in helmet-mounted information technology, artificial intelligence, large scene visual simulation for training, and logistics technology directly relate to major laboratory initiatives.

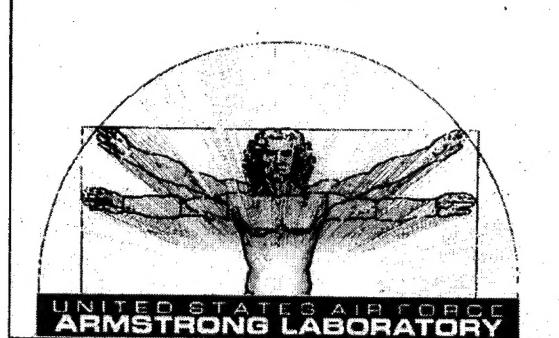
Small Business Innovation Research (SBIR) initiatives in support of all five technology thrusts address the specific needs of the Air Force research programs, as well as produce innovative dual use technology products. Representative technologies include advanced night vision goggles, on-board oxygen generating systems, and hyperbaric chambers. In a Phase I effort, Night Vision Corporation successfully demonstrated a Panoramic Night Vision Goggle (PNVG) with an exceptionally wide field-of-view of 100° horizontal by 40° vertical.

In a Phase II follow-on, they are integrating this optical system plus an electronic display into a visor/helmet. The low-profile PNVG will be more ejection-safe. The electronic display will provide targeting information and selected aircraft instrumentation. The pilot can then see these data without diverting attention from the outside world. The Helmet-Mounted Systems Technology Program Office provided an additional \$2.1M in funding to this program. Another company, Creare Inc., is commercializing a closed loop cryogenic refrigerator that can liquefy oxygen for med-evac or field hospital applications. A uniquely designed turbomachine and compact heat exchangers developed with SBIR funding are critical components of the system. Finally, a hyperbaric oxygen chamber constructed of concrete has proven to be successful beyond original expectations. This was a Phase I project last year and its objective was to substantially reduce the cost of constructing these chambers. The chamber was constructed and tested at Brooks AFB. It was able to withstand double the pressure originally predicted before it failed and initial cost estimates for construction indicate savings of 90 percent over typical steel chambers. The proof of concept can lead to significant growth in the hyperbaric oxygen therapy marketplace as more clinics and hospitals will be able to afford a lower cost facility.

Technology transfer activities often begin with assessments of human systems technologies by outside business strategists to determine which technologies have the greatest commercial potential. Results of these assessments are used in various marketing strategies to identify potential licensees for patented inventions and industrial partners for collaborative research.

The laboratory currently has 35 active Cooperative Research and Development Agreements (CRDAs), 25 Educational Partnership Agreements (EPAs), and numerous others in various stages of development. In addition, the laboratory has negotiated license agreements which have yielded royalty payments during the past year.

Examples of the technologies being licensed include our molecular sieve oxygen generation system for commercial use



Human Systems technologies are pervasive across all Air Force operations and are significantly leveraged by complementary research efforts underway in the academic, industrial, and international sectors. There are also close interfaces with other technology area programs through formal coordination and memoranda of understanding (MOU).

With few exceptions, current Independent Research and Development (IR&D) programs focus on the Crew Systems and Human Resources thrust areas. During the past several years the IR&D program has changed significantly. The

in health care, welding and cutting, and other industrial processes where low volume, high purity oxygen is a requirement; and our intelligent tutoring software that assists students in improving their math, reading, and science skills. A license agreement covering five laboratory patents has recently been signed with BeamTech, Inc., a San Antonio start-up company. It is anticipated that this licensing will generate royalties and further the application of Armstrong Laboratory technology to the market place.



Support of Human Systems technology is also obtained through cooperative International Research and Development efforts. The Armstrong Laboratory has received \$2.6M of Nunn Program funds for FY97 and is projected to receive \$2.525M in FY98. Two MOUs are in place, and twelve MOUs have recently been signed which will allow for participation through annexes. We currently have eight Project Annexes to MOUs and we participate on 15 data exchange agreements with foreign countries. The international program covers the range of laboratory research and development.

Coordination with other Air Force laboratories has continued to increase as a result of major Air Force laboratory restructuring that occurred in 1991. The Joint Cockpit Office managed by Armstrong Laboratory and Wright Laboratory coordinates a broad cockpit technology development program integrating exploratory and advanced development initiatives within the Human Systems and Air Vehicles technology areas. Previously established collaborative programs in the area of logistics technology with the Wright Laboratory have been strengthened. Wright and Armstrong Laboratories also have cooperative programs in the improvement of safe ejection seat envelopes, toxicological analysis of Halon replacements, and laser eye protection goggles. A cooperative program to advance directed energy technology has flourished between Armstrong and Phillips Laboratories. Formal technical exchanges have been initiated between Armstrong and Rome Laboratories to expand cooperation and develop collaborative initiatives in the areas of C3I training and decision aiding, human-computer interface technology development, and information dominance.

Armstrong Laboratory has also been very active in relocations under Project Reliance. Six chemical defense

researchers are collocated with the Army at Aberdeen Proving Ground, MD, while three training researchers share Navy facilities in San Diego. A total of 46 Army personnel are collocated at Armstrong Laboratory facilities sharing research ideas in biodynamics, laser and radiofrequency radiation bioeffects, and toxicology. Currently there are nearly 50 Navy personnel that are collocated at Brooks and Wright-Patterson AFB. This includes the Navy personnel who for 17 years have worked alongside Air Force researchers making breakthroughs in toxicology. These consolidations save money and increase the quality of research benefiting the users in all Services.

The integrated multidisciplinary approach used by the Armstrong Laboratory to attack human systems deficiencies across all USAF mission areas continues to feature the cross directorate team approach. In addition to the Situation Awareness Integration Team, the Advanced Technology Anti-G Suit, and the Large Rocket Motor Disposal program already in place, Armstrong Laboratory created teams to chart S&T initiatives in non-lethal technologies and information warfare.

The non-lethal technologies team has already helped Armstrong Laboratory establish itself as the USAF lead in the critical bio-effects S&T for non-lethal technologies and is restructuring our initiatives in this area. The information warfare team developed a joint effort with Rome Laboratory in Defensive Information Warfare.

Technological advances have opened new opportunities for investment in human-centered campaign planning at the strategic, operational, and tactical levels of war, including opportunities in information warfare, and psychological effects of both lethal and non-lethal operations.

Finally, strategic planners at Armstrong Laboratory identified areas for increased emphasis by focusing on the needs of the warfighter, the status of technologies, and conducting a thorough business review. These new emphasis areas include the following: crew performance and effectiveness aiding technology, visual and aural display technology, training the warfighter, and optical radiation countermeasures.

Work has also begun in the areas of identifying new technologies to improve foreign object debris (FOD) pick-up on the flightline and cleaner, more portable energy sources for AGE equipment. New intelligent logistics information systems are being developed to support wing commanders in the management of day-to-day operations in pre-and post-deployed environments by providing real time information on asset quantity and location.

---

## MAJOR TECHNOLOGY THRUST 1: CREW SYSTEMS

---

### USER NEEDS

---

**The Crew Systems Thrust** provides the warfighter a competitive edge by developing human-centered technologies which improve human performance, protection and survivability in operational environments. Products include: human-system design guidelines and automated design tools for the development of effective systems for information display, control interfaces, emergency escape, acceleration and altitude protection, and aircrew life support.

- **Joint Helmet-Mounted Cueing System.** User requirements documents include USAF/Navy Joint Mission Needs Statement, CAF 308-93, and Operational Requirements Document (ORD), CAF-USN 308-93-I-A. Our advanced development program for Helmet-Mounted Sensory Technologies (HMST) addresses the requirements for an improved helmet-mounted tracker and display (HMT/D) and a better night vision goggle (NVG).
- **Mission Area Needs.** As part of the USAF Modernization Planning Process, each using command has linked its role from national strategy to specific mission areas, defined each mission area's operational needs, and solicited concepts for satisfying the needs. Over two hundred needs have been correlated to Crew Systems programs. We are using the correlations to continuously refine our investment strategy.
- **Accommodation of Women.** Implementing Secretary of Defense's decision to open assignments in combat aircraft to women requires design changes to ensure combat effectiveness and safety. Our efforts will provide policy makers with the cost, schedule, performance, and risk information they need to establish specific policies to expand pilot populations for combat aircraft.

---

### GOALS

---

To meet our users' needs in Crew Systems, Armstrong Laboratory (AL) will:

- Demonstrate technology that will expand the performance envelope of emergency escape systems to include adverse attitudes and speeds of up to 700 knots for the full pilot population.
- Provide a pilot's daylight within-visual-range aiming system for air-to-air and air-to-ground weapons delivery to permit high off-boresight targeting.
- Demonstrate adaptive, integrated, multisensory, human-systems interface technology for air and ground crews combining alternative controls, virtually-augmented displays, and real-time computational models of crew state.
- Develop human-system interface design guidelines and tools to ensure USAF information dominance.

- Develop crew system interface concepts for Unmanned Aerial Vehicles (UAV) design.
- Define the ergonomics of expanded male and female crewmember populations, and develop design principles and tools to best accommodate both males and females within current and future combat systems and equipment.
- Demonstrate new crew-centered design processes, metrics and software for relating human performance to system effectiveness, and design a simulation-based integration testbed to quantify future human design requirements.
- Develop analytical tools, testing methods, and criteria for the design and evaluation of personnel crash protection concepts and systems.
- Develop and demonstrate a set of cognitive engineering tools and methods to support design and acquisition of Information Warfare systems.

---

### MAJOR ACCOMPLISHMENTS

---

The Visually-Coupled Acquisition and Targeting System (VCATS) was successfully flight tested on an F-15C. The VCATS was able to cue a High Off-Boresight Angle (HOBA) missile for multiple target locks on a single pass. The VCATS Operational Utility Evaluation (OUE) will demonstrate improved Helmet-Mounted Display (HMD) component technologies, including an improved Helmet-Vehicle Interface, a modularized HMD design that supports in-flight interchangeability with NVGs, lightweight flex circuitry in the helmet and display unit, a high brightness "Hot Tube" miniature CRT, a new high-speed (240 Hz) head/helmet tracker, and the use of expanded up-look reticles for improved off-boresight cueing. VCATS is the baseline helmet display unit and provides technical risk reduction support for the Joint Helmet-Mounted Cueing System (JHMCS) Engineering and Manufacturing Development (EMD) program.

In FY96 a Memorandum of Understanding (MOU) was signed with the United Kingdom to jointly develop and evaluate multi-sensory virtual interface concepts, virtual display and control devices, and advanced helmet-mounted tracker and display [HMT/D] technologies for incorporation into advanced aircraft. These interfaces will incorporate virtual and non-virtual technologies targeted for aircraft implementation into the 21st century. This effort will focus on improving airframe operability, and where needed, developing state-of-the-art aircrew mission equipment component technologies, interface concepts, and software that is essential for improving the aircrew's warfighting ability.

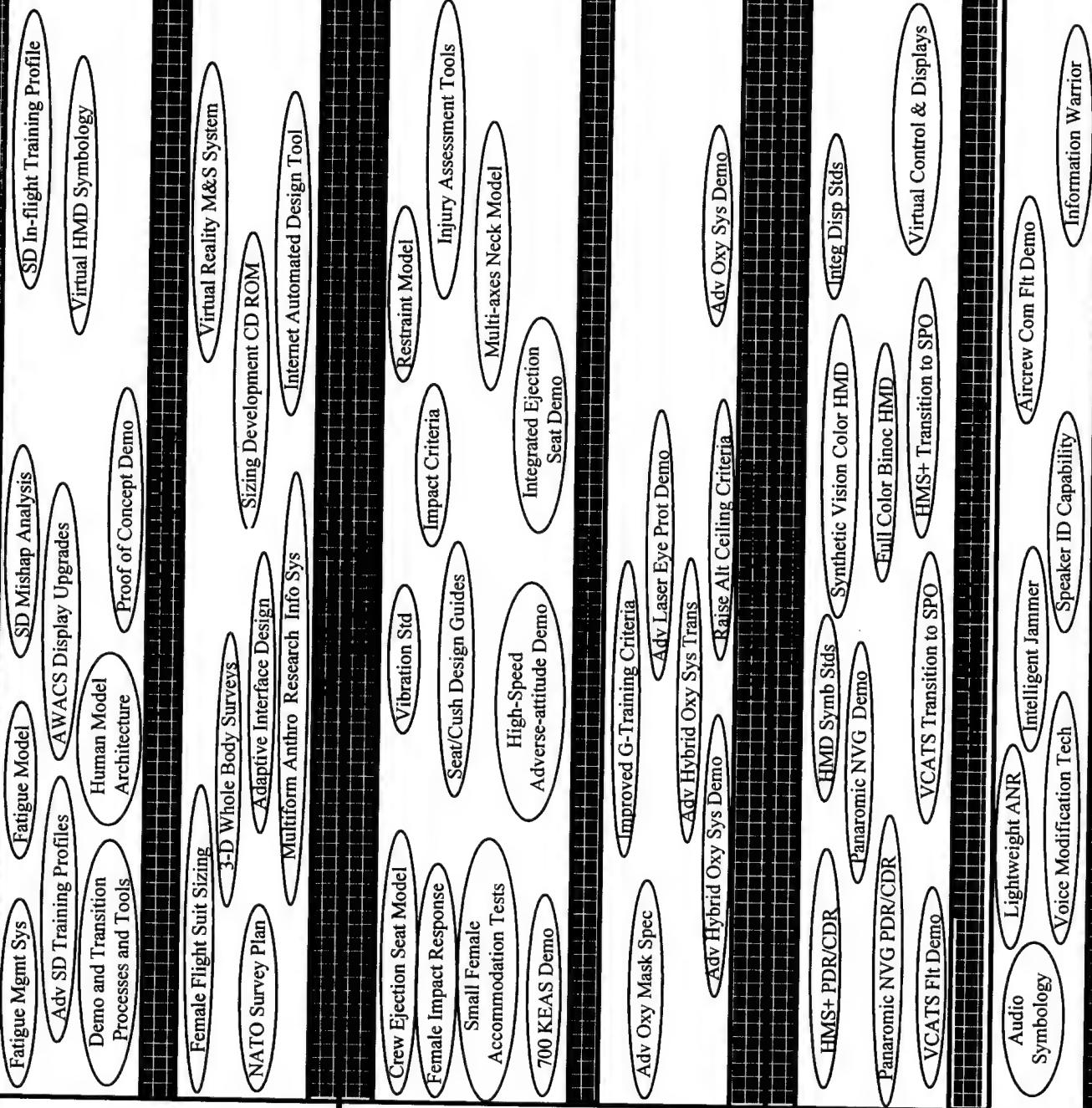
The Vista Sabre II OUE was completed at Nellis AFB NV, sponsored by Air Combat Command (ACC), demonstrating existing helmet-mounted tracker and display equipment under flight conditions.

# THRUST 1: CREW SYSTEMS

## SUBTHRUSTS

### **HUMAN-CENTERED DESIGN CRITERIA**

Assure effective integration of human operability considerations into the Air Force systems development process



Improve crew performance by defining and improving audio, visual, and other physical and psychological interfaces

Results pinpointed the operational and safety deficiencies of off-the-shelf systems, and guided our input to the formal operational and system requirements documents for the JHMCS EMD.

The Panoramic Night Vision Goggle (PNVG) working model had its first flight evaluation by the Army in a UH-1 helicopter. The PNVG demonstrated a greater field-of-view than the Army's current system. The PNVG also has been flown on Air Force Special Operations Command (AFSOC) Talon II and Pave Hawk aircraft as part of a quick-look flight test. Feedback has been positive.

We conducted the fourth US/French evaluation (Nunn Amendment funding) of a crew station incorporating US and French interface devices. Both virtual and conventional displays and controls were evaluated in a simulated combat environment at the Flight Test Center in Istres, France. Results indicated that this crew station design increased survivability and lethality over conventional designs.

Four of fifteen ejection seat tests have been conducted at the Holloman AFB High Speed Test Track as part of the Joint USAF/USN 4th Generation Escape System Technologies advanced technology development program to demonstrate controllable propulsion, flight control and windblast protection concepts. The 4th Generation system was integrated into an ACES II seat structure and tests were conducted at speeds up to 325 knots equivalent air speed (KEAS) under adverse attitudes (60° fixed roll). The remaining eleven tests will continue high-speed, low altitude, adverse attitude ejection at speeds of up to 700 KEAS. Upon successful completion of the ejection seat tests at Holloman AFB in FY98, the technology will be made available for transition/retrofit.

A USAF/Navy team developed the Integrated Helmet Audio/Visual System (IHAVS) and successfully demonstrated it on a Navy AV-8B Harrier aircraft. IHAVS enabled off-boresight targeting and navigation and improved the effectiveness and situational awareness of the single pilot in high workload missions. The system integrates a wide field-of-view binocular HMD, a four channel, 3-D audio display with active noise reduction, a voice control / recognition system, a helmet-position tracking system, a radar warning receiver, a target designation and tracking pod, and a smart weapon.

An engagement-level effectiveness analysis of target recognizer concepts for the F-15E Eagle was completed for the Aeronautical Systems Center's theater missile defense project. A towed-decoy study was also completed in support of the B-1B System Program Office (SPO), and the results were published.

Advanced whole-body, 3-D surface anthropometry measurements, along with whole-body center of gravity measures, were collected on males and females representing an expanded aircrew population. This is the first study of its kind. The intended use is for ejection seat safety, but it has potential for other applications such as protective equipment, crew station design and crew station evaluation.

A quick-look study was completed between the Crew Systems Directorate and Canada's Defence Civil Institute of Environmental Medicine to study the feasibility of using the Dynamic Environmental Simulator (DES) centrifuge to examine the "push-pull" effect on pilots. In the push-pull

maneuver, the aircraft goes from 1G to zero or negative acceleration, then immediately returns to medium or high positive acceleration. The push-pull maneuver decreases the pilot's positive G tolerance, which lowers the acceleration level required for the pilot to lose consciousness. The push-pull effect is now considered the cause of several mishaps and many other mishaps dating back to 1980 are being reexamined for this effect. With the advent of thrust vectored flight and more maneuverable high performance aircraft, the Push-Pull maneuver will be more easily accomplished, which may become more of a problem. The DES was able to replicate the push-pull maneuver and more studies are planned.

Modifications are being evaluated in the COMBAT EDGE and Advanced Technology Anti-G Suit (ATAGS) ensembles to allow these to be used by female aviators. Also, developed and demonstrated was a centrifuge model for assessing G-induced pilot fatigue resulting from successive simulated sorties. The combination of an ATAGS and the COMBAT EDGE positive pressure breathing system prevented or delayed fatigue, resulting in dramatically enhanced single- and multiple sortie capability in high +G<sub>z</sub> environments. A refinement of this protocol is being developed to study prevention of fatigue and preservation of performance using the new centrifuge fatigue model.

The Crew Systems Directorate produced two comprehensive updates to DDR&E's Defense Technology Area Plan (DTAP). This information was presented to DoD's Technology Area Review and Assessment (TARA) panel to assist in advancing this technology into the 21st century.

---

## CHANGES FROM LAST YEAR

---

In late FY96, a twenty-four month advanced development program was initiated to demonstrate the feasibility of a lightweight ejection seat based on the Russian K-36D ejection seat design. Requirements include accommodation of a larger range of crew sizes, a smaller headrest profile to increase aft vision, integration of US personal equipment, and ejection capable speeds up to 700 KEAS. The seat design is targeted for the Joint Strike Fighter (JSF) and will meet USAF and USN escape performance requirements. A Memorandum of Agreement is being developed with the Russian Government to assure continuity of the program, protection of intellectual property rights, and future manufacturing license agreements.

A Congressionally-directed program was initiated by the Crew Escape Technologies group in FY96 to verify the predicted performance of existing USAF, USN and USMC front-line trainer and tactical aircraft ejection seats for accommodation of lightweight occupants and to identify problems and required corrective actions.

Seven SIIS-3 ejection seat tests were conducted at velocities from 0 to 600 KEAS using a 103-pound manikin, representing the Lightest Occupant in Service (LOIS) and a 140-pound Advanced Dynamic Anthropomorphic Manikin, representing a small male crewmember. One static T-38 ejection seat test was also conducted using the LOIS manikin.

The remaining tests for evaluating the performance of the light weight occupants will conclude in mid-FY98.

Our crew-centered design project has been refocused on demonstrating technology to quantify future requirements, having completed development of an on-line design process. This desktop computer-based design process is undergoing beta testing at eleven locations in industry, NASA and DoD, and is a candidate for tri-Service use. A companion test and evaluation process embedded in a similar software tool, was distributed to, and is being used by, 65 separate test and evaluation organizations.

Our crew systems integration exploratory program was refocused toward work on collaborative systems, particularly in support of AF information superiority objectives. Individual and team coordination for UAV system operations emerged as a new research and development focus area and a study was undertaken to develop a coordinated industry-USAF technology roadmap for UAV research.

The Crew Systems Directorate completed its tri-Service leadership of the Joint Directors of Laboratories' Panel for Human Systems Interface technology, consisting of 39 senior managers from Service laboratories and product centers. The panel was transferred intact to DDR&E's Human Systems Technology Area, one of ten nationally recognized technology domains.

---

## MILESTONES

---

In FY97, additional VCATS flights will be made in two operational F-15Cs at Nellis AFB and in an F-15D at the Air Force Flight Test Center.

A version of the Panoramic Night Vision Goggle with head-up display symbology overlay will be delivered and tested in the VCATS-modified F-15Cs at Nellis AFB during FY98. We will expand the performance envelope of future helmet-mounted systems in FY98, enabling both day and night operations through the standardized interface. By FY00, we will test a full color binocular helmet-mounted display able to display fused symbology and imagery from sensors and weapons, and apply the result to UAVs in FY01.

Helmet-mounted displays, 3-D auditory localization, and force-reflecting controls are being integrated and evaluated jointly under our US/France MOU for Super Cockpit Technologies. In FY97, we will demonstrate the coupling of real-time computational models of pilot state, driven by physiological and behavioral measurements, to adaptations in control and display strategies. Warfighter evaluation of these innovative crew station concepts within complex and highly dynamic flight simulations will occur in FY98-99.

Using whole-body laser scanning, development of standardized international surveying methods will begin by FY98. In FY99, crew-centered design integration tools will be extended to distributed simulation environments. By FY01, we will demonstrate an Operator Integration Testbed concept, to quantify future crew system performance requirements.

Development of tools to analyze and model intracrew performance during coordinated joint operations commenced in FY96. As part of this work, a joint attack weapon evaluation will be completed in FY97 for the B-1B SPO. In FY99, a set of cognitive engineering tools will be developed to analyze and model multicrew performance. Cognitive

engineering will be applied to an advanced decision support system for intelligence analysts, following completion of a related field study in FY97. Information superiority and UAV operations are a near-term focus, concentrating on new models and tools to predict and assess intracrew collaboration. Models of distributed team situation awareness and team decision making will be completed in FY97. Lab testing will extend to FY00 to assess the use of these models for information dominance and UAV operations.

The Advanced Hybrid Oxygen System (AHOS) program encompasses the development of two systems: (1) a smaller, portable system (AHOS-Medical) for use in the ground medical and aeromedical evacuation environments, and (2) a larger capacity system (AHOS-Aircraft) for use in cargo/transport aircraft applications. These systems generate and liquefy high purity oxygen utilizing pressure swing adsorption and miniaturized cryogenic technologies. Because of their ability to meet peak flow rate requirements and generate high purity oxygen required for high altitude low observable missions and by the FDA in the United States Pharmacopoeia, AHOS-M and AHOS-A will meet USAF operational oxygen generation requirements where existing systems fall short. The AHOS-M technology demonstration system will be delivered to the laboratory in FY97 for integration, automation and analysis efforts. Preliminary design for the AHOS-A will be completed FY97 and the system will be transitioned in FY01.

The Advanced Aircrew Oxygen Mask offers solutions to problems of mask fit under high +G<sub>z</sub> acceleration and high mask pressures that exist for the COMBAT EDGE system or during high altitude unpressurized cockpit exposure. Innovative mask seal technologies will be investigated and rapid prototyping strategies will be exploited in FY97-98 to facilitate custom design for more correct mask fit. Transition is expected in FY98.

A collaborative effort was initiated with AL's Aerospace Medicine Directorate (AL/AO) to study the effects of therapeutic and operational drugs on acceleration tolerance and endurance. Plans are to develop and test a template for operational drugs which is similar to the existing therapeutic drug template employed by AL/AO. A new collaborative effort also has been initiated with AL's Human Resources Directorate regarding the tradeoffs between flying and flight simulation for F-16 pilots. In this developing proposal, investigators from AL and the Air Warfare Center (Nellis AFB) will determine how replacement of actual flying hours with simulation training affects pilot adaptation to the actual flying environment. We will also focus on G layoff effects associated with increased simulation training at the expense of actual flying. We are working (under a DARPA program) with the Navy and Army to develop a single patient transport unit with critical care monitoring and diagnostic capability that will traverse the entire aeromedical evacuation system. The first prototype will be ready for airworthiness evaluation in FY97.

FY97 marked the beginning of a collaboration between the National Highway Transportation Administration and AL to develop a PC-based Biodynamics Work Environment in which their respective databases and models can be accessed and used to conduct virtual experiments.

First-ever research on female task performance in the 7-9G environment was accomplished during FY96. Females flew simulated air-to-air combat sorties on the DES centrifuge; their performance was measured as they performed tracking and communications tasks. At 1G, the females' performance was comparable to males' performance. Some gender differences were found; none of the results indicated that women should not be allowed to pursue careers in fighter aircraft.

---

## MAJOR TECHNOLOGY THRUST 2: HUMAN RESOURCES

---

### USER NEEDS

- **Recruiting, Selection, and Retention (AF/DP).** The Air Staff needs advanced tools to address new challenges in recruiting, rising attrition, and decreasing performance, all of which have been exacerbated by an outdated classification system.
- **Dynamic Force Planning (ACC, AMC).** AF field commanders need quick response tools with intuitive graphical interfaces to assist in personnel management and monitoring of deployed forces. Also needed are historical archives to track exposures to potentially adverse substances.
- **Information Superiority (AF Core Competency, USAF/CC).** Commanders must be able to assess the vulnerability of their people to enemy information warfare operations and have strategies for neutralizing these attacks. The AF must be able to tailor information operations to capitalize on enemy psychological weaknesses, while accounting for cultural differences in the opposing forces.
- **Planning and Evaluation of Education and Training (AETC).** AETC and follow-on training agencies need methods to ensure that training systems are designed and implemented to yield the largest possible return on their investment.
- **Planning for Affordable Lifecycle Training Applications (AETC, ACC, AMC).** As resources shrink, users need a comprehensive set of methods to analyze the mix of training – both development and delivery systems -- for the warfighter.
- **Globally Distributed Team Training (ACC, AMC).** Operators and maintainers need high fidelity, low cost virtual training environments to provide faithful, unconstrained mission training. Cognitive models are needed to provide constructive simulations of human performance. With geographically separated units, there is a need to provide distributed, real-time training..
- **Cognitive Task Analysis and Engineering (ACC, AMC, SPACECOM).** Units are now experiencing performance degradation due to operator overload in technologically advanced systems. Users need to know the cognitive demands of the workplace to deliver specialized training for cognitively complex tasks and high information-flow environments.
- **Intelligent, Computer-Aided Instruction (AETC, AMC).** Operational commands need to reduce the cost, time, and expertise required to produce and maintain individualized, adaptive tutors that meet their “just-in-time” training needs.
- **Aircrew and Maintenance Training Systems and Devices (ASC/YWB and Tech Push).** As the USAF draws down its bases overseas, it needs to provide

deployable training capability to its aircrews on TDY to remote locations.

- **Distributed Mission Training (ACC and AETC).** Aircrews need high fidelity, low cost virtual training environments to provide unconstrained combat mission training.
- **Situational Awareness Research (ACC and AETC).** The Air Force needs to measure and train situational awareness. Applications include the training of team skills for combat visual identification.
- **Night Vision Device (NVD) Training (AFSOC and ACC).** The DoD needs deployable ground-based training to utilize NVD technology effectively and prepare aircrews to fight at night.
- **Mission Rehearsal Strategies and Measures of Effectiveness (ACC, AETC, AFSOC).** These MAJCOMS need strategies for mission rehearsal, distributed mission training opportunities via synthetic environments, and measures of effectiveness for all training levels.
- **Technologies to Support Flexible Contingency Operations and Deployment Support (ACC, AFMC, AMC).** ACC and AMC explicitly highlighted as a major concern the need to decrease the deployment “footprint” and overall support “tail” for logistics.
- **Integrated Technical Information for Field and Depot Maintenance (All operating MAJCOMs and AFMC).** All commands are vitally interested in reducing the cost and time of flightline and depot maintenance through use of advanced electronic troubleshooting aids and electronic technical manuals.
- **Technology for Design and Maintenance (AFMC and Tech Push).** US airframe builders, depot maintainers, and commercial industry need aircraft support technologies, design trade-off tools, and business re-engineering tools to increase productivity, reduce operational costs, and increase system affordability.

---

### GOALS

---

In order to meet our users' needs in Human Resources technology, the Armstrong Laboratory will:

- Develop state-of-the-art methods to 1) recruit, select, and place personnel to optimize performance in complex, stressful and information-laden environments, and 2) ensure retention of a right-sized force with the appropriate mix of skills.
- Develop ways to evaluate and enhance the mission impact (faster, better, cheaper) of advanced training technologies.
- Build decision aids for real-time use that can help planners structure effective information warfare and psychological operations campaigns.

## THRUST 2: HUMAN RESOURCES

### SUBTHRUSTS

#### COGNITION AND PERFORMANCE

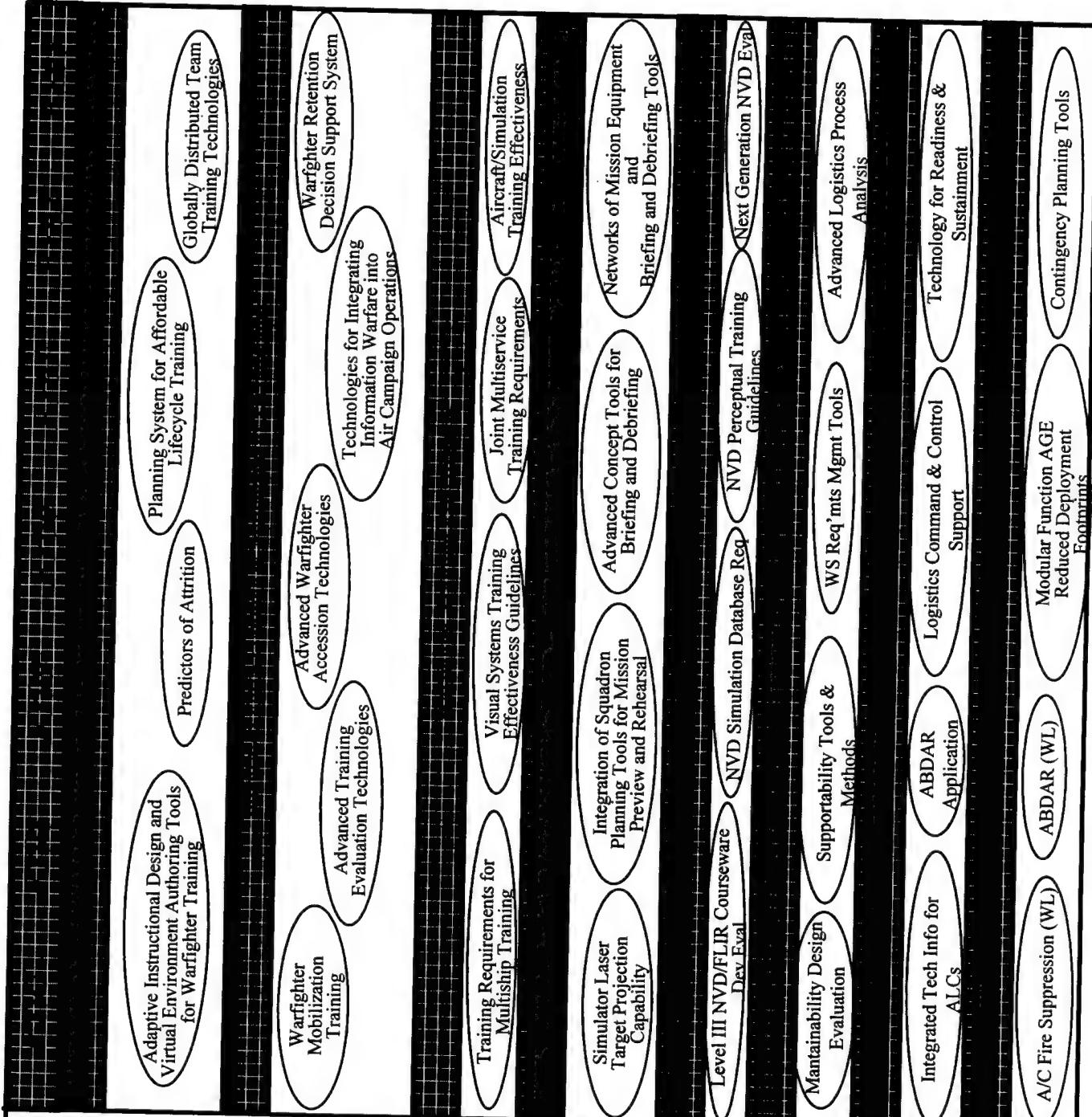
Intelligent Computer Assisted Instruction Authoring Systems  
 Adaptive Training Planning & Design Support Systems  
 Distributed Team Training  
 Virtual Environment Training  
 Team Performance Models  
 Attrition Screening Prediction Tools  
 Cognitive Task Analysis Methods & Tools

#### AIR WARRIOR TRAINING

Warrior Training Systems  
 Unit Level Training  
 Mission Planning/Rehearsal  
 Low Cost Simulation Systems  
 Night Vision Device Training  
 Advanced Training Methods  
 Training Effectiveness Evaluations

#### LOGISTICS SYSTEMS

RM&D Engineering Design Tools/Methods  
 Integrated Maintenance Information Technologies  
 Contingency & Deployment Tools/Methods  
 Technologies for Supportability



- Design quick-response tools to assist commanders with dynamic force planning and execution of deployments.
- Develop models of real-time, complex thinking during stressful, overloaded conditions to improve personnel selection, training and weapon system design.
- Build tools to enable commanders to plan, execute, and refine training to achieve the most cost-effective mix of development methods and delivery systems.
- Invent the technology applications that permit effective individual and team training for every warfighter and ops support member, plus make it available throughout the world.
- Develop technology to produce computer-based instruction in one-tenth the time and one-tenth the cost of current development methods.
- Develop and evaluate advanced instructional techniques and methods for air warrior training
- Develop and evaluate simulation technology for deployable networked aircrew mission trainers at one-tenth the cost of current weapon system trainers.
- Develop and evaluate deployable night vision device training technology.
- Develop and evaluate Distributed Mission Training (DMT) guidelines and technologies that will allow the MAJCOMs to fulfill current CSAF direction to conduct distributed mission training..
- Develop, implement and evaluate the data and information needs of the squadron of the future, Squadron XXI, to create an information management system serving the needs of the warfighter, from the individual pilot to the wing commander.
- Develop technologies to increase supportability and affordability of Air Force weapon systems.
- Continue focus on increased system supportability, battle damage assessment/repair, reengineering logistics processes, and multifunction/modular support equipment.
- Demonstrate integrated logistics deployment planning and execution tools, including information systems, and asset visibility with special focus on support to the Air Expeditionary Force (AEF) initiative.
- Extend and demonstrate innovative integrated technical information tools that will reduce the cost and time of aircraft flight line and Programmed Depot Maintenance at Air Logistics Centers.
- Develop/demonstrate advanced logistics support tools for UAVs and future space planes.

---

## MAJOR ACCOMPLISHMENTS

---

Cognizance and performance modeling research produced an automated approach to data collection of job information needed by the training community and to analyze force structure requirements. This automated technology will reduce the cost and time required to collect the needed information.

We studied how the AF enlisted promotion system should be changed to provide a fairer promotion opportunity for personnel in certain career fields (those without specialty knowledge tests). AF/DP implemented our recommended

changes as official AF promotion practices. Based on our study of changing demographics in the AF we initiated an evaluation of future recruiting strategies and compensation alternatives. Interest in high attrition among first-term airmen spawned research to identify and evaluate factors which may predict these losses. Cognitive task analysis work led to restructuring of the Air Weather Service weather stations, Crypto Linguist training systems for AIA, and the Personnel Decision Support System for AF/DPC. We also developed two models of human thought processes, one representing an individual's situational awareness of objects moving in space and one for a person's propensity for taking risks with respect to costs and benefits. These models will be used to develop selection and training technologies.

We demonstrated a cost-effective technology to develop adaptive tutors for operational use and transitioned the products of these demonstrations to our users. We demonstrated and transitioned an adaptive tutor for radar to the joint UNT school at Randolph AFB and a tactical decision-making tutor to the U.S. Army Armor Center. We deployed an intelligent tutor to the Fleet Training Center in San Diego, which teaches students a hazardous maintenance procedure for shipboard systems. We also completed the initial version of a technology to develop virtual reality based tutors and used it to build a complex voice/virtual reality tutor to teach students how to communicate with aircrews during takeoff or landing.

Research in aircrew training technology has resulted in a number of significant advancements during the past year that will improve the quality of training and lessen the cost of training in the out years. We demonstrated a proof of concept of a deployable mission training environment which included a four-ship of F-16s, two A-10s, and a C-130 all on a local area net flying a typical combat mission scenario. The demonstration also included mission planning, air weapons director station, brief/debrief, advanced electronic classroom, night vision goggle imagery, and two T-38s. We used the distributed mission training testbed to support an OSD-sponsored exercise in the development of tactics and doctrine for Joint Combat Search and Rescue missions.

The utility of an eye tracker as a training aid for T-37, F-16C and F-16C LANTIRN simulator training programs was demonstrated. Substantial improvements were made to the comfort, ruggedness and set-up requirements of the eye tracking system. Preliminary results from the users support expanded use of the system. Results indicate that training quality and efficiency are improved due to improved instructor feedback and more accurate diagnostics of problem areas.

We developed guidelines for effective management of team training in the Special Operations formal annual refresher course, resulting in higher probability of successful mission outcomes.

To meet the unit level training needs of the USAF Reserves, a C-130H and an A-10 training device were completed providing high fidelity mission training capability at a tenth the cost.

The warfighter's ability to fly effectively and safely at night was improved by providing in theater training in the use of night vision goggles (NVGs), conducting numerous cockpit

lighting compatibility evaluations, updating courseware materials, and assisting in the development of a concept of operations for tactical weapon systems. Additionally, we have developed an advanced helmet mounted display for simulating night vision goggle imagery for use in a deployable training system.

We completed the development of a multi-level security manager for use in distributed mission training environments. We also developed a low cost reconfigurable ground based Uninhabited Air Vehicle (UAV) training research testbed and ground control station that can be integrated with the synthetic battlespace to address questions of critical concern for the development and use of future uninhabited aerial vehicles. In conjunction with the Army Research Institute and the Naval Air Warfare Center, we developed training measures to assess the performance of selected mission cells during Blue Flag 97-1.

New tools to improve deployability, affordability, and operation of systems were fielded. We identified user requirements for logistics technologies to support rapid and flexible deployments, joint-Service operations, wing-level information systems, and integrated information systems to support Programmed Depot Maintenance (PDM). Some of these new tools supported the B-1B and E-3 PDM lines at Oklahoma City ALC.

The first phase of a program to develop integrated information tools to support the PDM process at all USAF Air Logistics Centers was completed. Products included Business Case descriptions of the best practices found in the five ALCs. A major milestone was achieved by the transition of the Integrated Model Development Environment software tools to the Air Force Management Engineering Agency to replace the Logistics Composite Model, the standard USAF logistics manpower modeling tool.

Significant progress was made on modeling and design analysis tools that allow users to work with new systems designs and capabilities before the systems are actually built. Several trial applications have been made in coordination with the B-1B program managers at Oklahoma City ALC. This unique combination of software can simulate human maintenance performance with physically accurate computer animated models.

The first phase of a program to develop an automated battle damage assessment and repair (ABDAR) system was completed. The information requirements for an ABDAR system were completed, IDEF "AS IS" and "TO BE" models were developed, and a preliminary system design was completed. Work was initiated on the follow-on phase to develop and test a demonstration ABDAR system.

Work was initiated on a comprehensive analysis of the deployment process. The analysis of the current processes was completed and an "AS IS" model developed. Work was initiated on a "TO BE" model which will apply new technologies at key points in the process to make deployment operations more efficient and faster. An advanced development program that incorporates advanced modeling, engineering, environmental, and human maintainability design tools in a multi-function aircraft support system was selected as a "Model Affordability" Program by the DDR&E's Affordability Task Force.

The Integrated Requirements System Test Bed, an essential enabling technical element to successful integration of the new Air Force Long Range Plan and current Modernization Planning Process received overwhelming support from the MAJCOMs and the Air Force Requirements Council (AFROC).

---

## CHANGES FROM LAST YEAR

---

The Human Resources Thrust was reviewed by the USAF Scientific Advisory Board in their 1997 Science and Technology Review. The work being performed under the Human Resources Thrust was rated "I - Best anywhere, world leader."

The Force Management Methods and Tools and the Technical Training Subthrusts merged to form the Cognition and Performance Subthrust, an integrated manpower, personnel, and training research program. The direction of this new Subthrust is aligned along AF Core Competencies with an emphasis on operational customers.

---

## MILESTONES

---

In FY98 we will develop technologies to predict the attrition of airmen who are in their first-term of enlistment to help decision makers reduce early losses in the future.

We will complete a prototype cross-cultural psychological operations planning tool and begin work on assessing the information warfare vulnerability of friendly forces – both of these efforts have been requested by AIA to enhance their core competency of information superiority.

Training evaluation research in FY98 will provide AETC with tools to analyze the return on investment for both individual and team training. Also in FY98, we will deliver the first prototype of the Deployed Forces Information and Evaluation System (DEFINES), a personnel asset tracking system for use by Air Expeditionary Force commanders to create the best force mix. By FY02 we will have initial operational capability of DEFINES. In FY99, we will deliver to the AF/DP a new classification system for assigning first-term airmen to enlisted career fields, thus enhancing person-job matches and reducing attrition.

FY98 will see delivery of cognitive task analyses for the enlisted weapons director and unmanned aerial vehicle operator specialties, for use by Armstrong Laboratory in developing synthetic task environments. In FY98, we will demonstrate a tutor that teaches weather forecasters how to use satellite data in a tactical environment, evaluating the effectiveness of basic instructional techniques embedded in flexible, cost-efficient delivery tools. We will begin work on adaptive training in distributed environments, paving the way for the development of highly flexible and effective training tools to be delivered anytime, anywhere.

Also in FY98, a virtual reality adaptive training tutor for maintenance of F-15 armament systems will be evaluated at Sheppard AFB, to see the effectiveness of placing technical training into a three dimensional environment. We will also

demonstrate a virtual reality-based trainer for air traffic control systems in FY98.

NVG simulation database requirements will be delivered in FY98 and Night Vision Device (NVD) perceptual training guidelines will be delivered in FY00. We will complete an NVD training system demonstration by FY01. Warfighter training effectiveness S&T will deliver training technologies for multiship training and Air Force Special Operations Forces training guidelines in FY98. Validated mission rehearsal and situational awareness training strategies and visual systems training effectiveness guidelines will be delivered in FY99-00, respectively. In FY01-02, joint service training requirements and Uninhabited Combat Air Vehicle (UCAV) training technologies will be developed.

In the area of Distributed Mission Training S&T, a simulator laser projection capability will be developed in FY98 and optimized for use as a simulator visual display improving ability to detect targets at realistic ranges. Integration of squadron planning tools for mission preview and rehearsal will be completed in FY99. Implementation of an F-16 fourship vs. many multiship air to ground testbed baseline will be completed in FY00. An advanced threat simulation and control capability will be implemented in FY00. Training effectiveness of the four-ship distributed mission training testbeds will be completed in FY01. Tools for advanced real time instruction, briefing and debriefing will be completed in FY00 with guidelines for use in a networked training environment completed in FY02. A demonstration of a training oriented exercise involving live, constructive and virtual participants will be completed in FY01.

In FY98, we will develop and field test tools to improve logistics deployment planning and execution and new design tools for assessing maintainability of new avionics retrofits for operational aircraft. In addition, analytic information modeling tools will continue to be developed and tested to improve weapon system affordability and supportability.

Unique user requirements associated with rapid deployment scenarios and joint Service operations will also be identified. In particular, we will work with other AFMC agencies and DoD Services to identify how rapid deployments impact logistics at the home station and at deployed locations. Special challenges include the identification of unique user requirements for logistics technologies to support rapid and flexible deployments, joint-Service operations, and wing-level information systems and integrated information systems to support Programmed Depot Maintenance at the Air Logistics Centers.

In FY98-99, using a combination of commercial products, special purpose programs, and analytic methods, we will develop and field test wing level logistics deployment planning tools that can decrease the overall reaction time to respond to contingency operations, reduce logistics footprints, and increase overall logistics asset visibility.

With Integrated Weapon System Management now becoming fully implemented, synthetic environments using advanced analysis and simulation tools will soon allow assessment of manufacturing, production, logistics deployment readiness, and weapon system operational suitability prior to manufacture/retrofit. We will demonstrate in FY99 the performance and cost advantages of fully integrated information systems to support PDM. Also in FY98, we will complete the design for an integrated technical information system for ALCs to perform PDM and develop the demonstration tools.

In a cooperative program with Wright Laboratory, we will combine previously developed digital information technology and advanced computer graphics to develop self-contained, hand-held, aircraft battle damage accident assessment and repair aids. With this, field personnel can make rapid, on-site judgments about aircraft mission capability and dramatically reduce the need for volumes of paper technical data and large numbers of engineering specialists. We will also complete a user requirements analysis to identify ALC needs in aircraft maintenance and modification that impact aircraft life extension.

---

## MAJOR TECHNOLOGY THRUST 3: AEROSPACE MEDICINE

---

### USER NEEDS

---

- **Tasking from USAF Surgeon General (USAF/SG).** Evaluate referred aircrew with difficult, borderline, or unique aeromedical problems using specialized studies and examinations to determine the appropriate flying disposition recommendation. Manage the Enhanced Flight Screening-Medical (EFS-M) program.
- **Operational Performance Enhancement Devices and Physiological Optimization (AFSOC, ACC).** Evaluate and improve aircrew visual performance when using night vision systems. Develop and update methodology for the USAF aircrew contact lens program. Evaluate refractive eye surgery for potential application in aircrew. Develop advanced visual performance testing to evaluate the impact of medications, eye diseases, and provide for earlier disease detection. Develop a new aircrew spectacle safety frame and lens materials compatible with current life support equipment. Develop operational applications for eye tracking, corneal topographic analysis, haze/glare analysis, and advanced imaging techniques. Enhance aircrew performance through improved fitness program, development of a practical, applied cognitive skill assessment and facilitation program and develop an aircrew health maintenance program. In cooperation with the Crew Systems Directorate determine  $G_z$  exposure limitations for the prevention of radicular symptoms and cervical/lumbar pain. Conduct physiological, gender-specific, aerospace operational technology development. Provide operational analysis of aeromedical factors in aircraft mishaps.
- **Development of Aircrew Physical Standards (ACC, AMC, AFSOC).** Conduct human performance research to identify significant physiological risk factors. Regulate physical standards for USAF special tactics teams with US Army Rangers, US Navy Seals, and Coalition special operations forces. Evaluate the impact of refractive surgery on operational visual performance. Quantify the successful aircrew mission and weapon system specific attributes. Improve psychological and physical testing tools for aircrew selection. Evaluate the aeromedical significance of coronary artery disease, embolic/ischemic events, and cardiac dysrhythmias in high  $G_z$  environments. Develop a method to detect asymptomatic cardiac ischemia, aircrew laser surveillance induced color vision changes, risks for aircrew with spinal disease, and severity indicators for closed head injury using state-of-the-art neuroanatomical modalities. Develop advanced methodologies and performance based revision of aircrew vision standards.

---

### GOALS

---

In order to meet our users' needs in Aerospace Medicine, the Armstrong Laboratory will:

- Maintain an ongoing current and accessible aircrew aeromedical standards database that identifies disease cohorts, subsets, and cofactors.
- Identify physiological risk factors which adversely impact aircrew operational success.

- Detect diseases with long asymptomatic latent periods in aircrew trainees prior to training.
- Develop improved tools for disease assessment to permit early intervention, decelerate the rate of progression, and prevent morbidity and premature mortality.
- Develop objective guidelines to remove from flying status, either temporarily or permanently, those aircrew with clinical or preclinical disease which pose an unacceptable flight safety risk.
- Develop psychological screening tools and techniques which facilitate establishment of aircrew norms and improve the identification and selection of successful aircrew.
- Develop tools to delineate the unique psychological and aeromedical needs of female aviators in deployment and combat situations and in mixed-gender units.
- Develop noninvasive audiologic and vestibular diagnostic systems to identify individuals more susceptible to noise injury. Develop new exposure standards for hazardous occupational noise. Detect early-stage vestibular disease and evaluate vestibular performance.
- Enhance aircrew performance by designing optical/visual appliances and protective devices, by developing a psychological instrument to assess cognitive performance strategies, and develop physiological technology to define fitness, health, and gender-related factors.

---

### MAJOR ACCOMPLISHMENTS

---

In collaboration with AL's Occupational and Environmental Health Directorate, and other federal agencies, the threat from commercially operated lasers near military and civilian airfields continued to be successfully controlled by working with the FAA and NTSB to develop guidelines for such devices. Exposed aircrew received comprehensive evaluations to assess impact of laser exposure on visual systems. On behalf of NATO-AGARD, a Laser Bioeffects Workshop was held and recommendations made to enhance aircrew awareness and protection.

Using normative data gathered during a previous baselining project, over 600 applicants have been evaluated for aviation special duty assignment with AFSOC, involving three different aviation mission areas. The overall applicant rejection rate remains about 20%, while training and other failures are down from about 18% to 3-5%. Another estimated 100 NASA astronaut applicants will be screened in FY97/98 using previously developed processes.

The Armstrong Laboratory Aviator Personality Survey (ALAPS), a new aviator personality assessment tool, was completed and normed for the aviator population. This instrument is currently in use assessing student pilots in the Enhanced Flight Screening Program. The instrument is now available and distributed through CSERIAC.

After deriving a regression equation for coronary disease risk from the retrospective analysis of a group of 818 aviators who underwent cardiac catheterization, the Clinical Sciences Division (CSD) collected data prospectively on the next 68 aviators undergoing angiography.

## THRUST 3: AEROSPACE MEDICINE

SUBTHRUSTS	SUBTHRUSTS	
<b>AIRCREW STANDARDS</b> <b>RESEARCH</b> Provide medical selection criteria in extending the flying lifetime of current pilots by reducing medical groundings  Disease - Early Detection and Definition of Effects	<b>AIRCREW STANDARDS</b> <b>RESEARCH</b> Atrial Fibrillation Standards CAD Risk Equation Exercise Echo  Atrial Fibrillation Standards Exercise Echo  Echo Response under high Gz Therapeutic Drugs in Aviators	
	<b>AUDIOLOGIC &amp; VESTIBULAR AEROMEDICAL STANDARDS</b>  Aircrew Vision Survey Report New Color Vision Standards New Management Group Subsets PRK Studies  Closed Head Injury Study  Established Aircrew Norms  Revised Psych Standards  Revised Neuro Standards	<b>AUDIOLOGIC &amp; VESTIBULAR AEROMEDICAL STANDARDS</b>  Aircrew Sunglass Material Recommendations  New Color Tests  NYG/Eye Pathology Standards  Corneal Topography Study  NYG Manual Update  New Aircrew Sun Visor  Revised Performance Based Vision Standards  Psychological Performance Strategies
<b>OPERATIONAL PERFORMANCE ENHANCEMENT</b>  Enhance and protect aircrew performance- - Optical & Visual Appliances - Gender-Specific Physiological Effects - Psychological Performance Effects		<b>AEROMEDICAL INFORMATICS</b>  Assess & Linkage - All levels USAF Aeromedical Standards

Selection of a threshold risk of 4.5% from the retrospective group would have resulted in 163 (20%) fewer catheterizations, while missing 3 cases (2%) of significant, and 10 cases (6%) of minimal disease. Using the same threshold in the prospective group would have resulted in 16 (24%) fewer procedures, while missing none of the 18 aviators with gradable disease. Because of the successful prospective validation of the regression equation, the CSD has begun using the coronary angiography decision equation (CAD) for initial evaluations of suspected coronary disease.

With the revolution in understanding of peptic ulcer as an infectious disease, the CSD revised the aeromedical standards governing waiver for peptic ulcer. The new standards reflect the role of *Helicobacter pylori* and its eradication in the management of ulcer disease.

A comprehensive review of NASA astronaut vision standards was completed. Contact lens use was expanded to include UFT. A comprehensive research program on the aeromedical issues of refractive surgery as tasked by the Chief of Staff of the Air Force was developed and initiated. A collaborative study with the US Navy was completed on NVG performance after photorefractive keratectomy (PRK). A new initiative to develop improved USAF firefighter selection and training standards was begun. Two new management subsets of established aircrew management groups were adopted on minimally defective stereopsis and early keratoconic corneal topography suspects to expand aircrew selection candidate pool.

A review of aviators with idiopathic ventricular tachycardia, from the V-tach management group, was presented at the American Heart Association meeting in November 1996. Aeromedical implications of ventricular tachycardia was presented at the Aerospace Medical Association (AsMA) conference in May 1997.

The natural history of mitral valve prolapse was presented to the meeting of the American College of Cardiology in March 1997. A study of aeromedical implications of prolapse was presented to AsMA in May 1997.

A Phase I Small Business Innovative Research (SBIR) program was completed, which established the possibility of constructing a flight simulator to evaluate cognitive deficit from medications. The Phase II proposal of that project was funded, and begun in the third quarter of FY97.

---

## CHANGES FROM LAST YEAR

---

The study of incidentally discovered mitral valve prolapse (MVP) was expanded. The original intent was to compare incidentally discovered MVP with those cases presenting with symptoms. Because of the complexity of the condition, it was deemed appropriate to add a control group of aviators with non-cardiac problems. Completion is expected in early FY97.

The decision package for the proposed new aircrew spectacle frame was delayed until FY97 and has been transitioned to DOD for a final tri-Service purchase decision. The delay allowed incorporation of data from the USAF Aircrew Operational Vision Survey, conducted by our Vision Enhancement and Eye Protection (VEEP) Integrated Product Team (IPT).

---

## MILESTONES

---

The first phase of the comprehensive USAF Aircrew Operational Visual Survey data analysis will be completed and recommendations made to the AFMOA staff for future research and support initiatives.

In collaboration with West Virginia University, new advanced visual performance tests were developed and validated which will help evaluate visual performance with systemic medications, laser protection, and ocular pathology, e.g., glaucoma and other eye diseases. A successful CRDA was established to develop a low cost portable advanced gamma camera for diagnostic medical scanning.

The AF/CC directed study to investigate the effects of Photorefractive Keratotomy (PRK) has begun. Wilford Hall Medical Center (WHMC) purchased an excimer laser and is ready to treat non-aviator patients who will then be extensively evaluated by Armstrong Laboratory personnel looking closely for cornea integrity, glare issues, and other effects on vision. The Head Injury study is ready to implement and will involve an overhaul of the regulations for aviators status post mild, moderate, and severe head injury.

The Lisinopril study will produce a recommendation to AFMOA late FY 1997 regarding aviator flying duties while taking this important antihypertensive medication.

---

## MAJOR TECHNOLOGY THRUST 4: OCCUPATIONAL AND ENVIRONMENTAL HEALTH

---

### USER NEEDS

---

- **Personnel Susceptibility to Directed Energy Systems**, (Air Combat Command, Air Force Special Operations Command, Air Force Surgeon General). This program determines human susceptibility to laser weapons for the purpose of developing laser eye protection. It also evaluates vulnerability of personnel to US systems, and emerging threats as well as possible countermeasures.
- **Active Denial Technology**, (Air Combat Command, Space Command, U.S. Special Operations Command (USSOCOM), U.S. Marine Corps, DEPSECDEF, Defense Special Weapons Agency). We are developing non-lethal technologies for the protection of high value assets, military operations other than war (MOOTW) and peace keeping operations.
- **Non-Lethal Technologies**, (USSOCOM, Executive Agent for Non-Lethal Weapons, U.S. Army Armaments Research and Development Engineering Center (ARDEC). This program determines human susceptibility to non-lethal technologies. It also characterizes the safe operation of U.S. systems, and examines possible countermeasures to emerging threats.
- **Directed Energy Safety Standards**, (Air Force Surgeon General, Air Force Safety and Health Regulations, NATO Standardization Agreement, Systems Technical Needs). This is a continuous program to protect Air Force personnel and the environment from possible hazards associated with emerging Directed Energy technologies (e.g., ultrashort pulse lasers, ultrawideband radiofrequency systems).
- **Operational and Environmental Toxicology**, (F-15, B-2, F-22 SPOs; Wright Laboratories Aero Propulsion and Power Directorate and Flight Dynamics Directorate; US Army Armament Center and Army Missile Command; Naval Weapons Center; USEPA; Air Force Pollution Prevention Strategy, US and Norway Bilateral Agreement, USEPA Environmental Regulations). The Toxicology Division conducts research in direct support to program managers and decision makers tasked with AF weapon system acquisition, modification and operations. Mandated phase out of chemicals (Halon and solvents in particular) drives current research for mission critical chemicals and product substitution. The ability to field the new materials depends heavily on the human health consequences associated with the use of these materials in military specific applications. Provide health effects research on chemicals that contaminate groundwater and soil to assist in determining realistic remediation requirements. The members of the Toxicology Division develop predictive tools to improve hazard interpretation in support of AF pollution prevention initiatives decreasing life-cycle costs of weapons systems. Toxicology research is also carried out in areas of fuels and propellants, working directly with AF system program

managers to create a scientific basis for decision making in the critical areas of operational performance, regulatory compliance and personal protective posture in military operations.

- **Environmental Noise**, (Air Force Civil Engineer, Air Combat Command, National Environmental Policy Act, Endangered Species Act, Marine Mammal Act). This research provides the development of tools for legally defensible environmental impact statements and environmental assessments to enable Air Force operations to execute as required.

---

### GOALS

---

In order to meet our users' needs in Occupational and Environmental Health, the Armstrong Laboratory will:

- Develop laser eye protection equipment for aircrew and develop human exposure standards to permit operations and minimize casualties in current and projected laser threat environments
- Assess the validity of proposed non-lethal technologies with respect to effectiveness, threat assessment, health and safety, and countermeasures
- Assess the effects of radiofrequency radiation to set scientifically based safety standards in day-to-day operations and protect personnel from future directed energy weapons and systems
- Develop national standards and tools to assess the effects of aircraft noise on people and the environment providing the Air Force a legal defense against lawsuits and keeping training routes and military operating areas open
- Reduce multi-billion dollar system life cycle costs up to six percent in outyears by providing materials safety and environmental assessments of potential toxicity.
- Develop effective, innovative methods for determining human/material operational interfaces that allow AF decision makers to optimize the use of militarily important chemicals and materials while minimizing the adverse health impact on DoD personnel.
- Establish scientifically defensible approaches for determining the risk-based clean-up (remediation) level for contaminated AF base property in order to ensure regulatory compliance and human safety without wasting AF dollars that could be better spent on AF weapon systems and operations.
- Provide flexible, responsive and militarily relevant toxicology support to program managers tasked with improving performance of fuels, propellants, lubricants, de-icing agents, explosives and fire suppressants.

## THRUST 4: OCCUPATIONAL AND ENVIRONMENTAL HEALTH

<u>SUBTHRUSTS</u>	
<b>TOXICITY</b>	<ul style="list-style-type: none"> <li>Jet Fuel Toxicity</li> <li>Fire Suppression Toxicity</li> <li>Next Generation Fuel Toxicity</li> </ul>
Identify hazards of operational chemicals and materials	
Propose exposure for limits for military operations	<ul style="list-style-type: none"> <li>Explosive/Propellant Toxicity</li> <li>JP-8 Environmental Standard</li> <li>Fuel System De-Icer Toxicity</li> <li>Heavy Metals Bio-distribution</li> </ul>
Conduct chemical-specific risk assessments for pollution prevention activities	<ul style="list-style-type: none"> <li>Rocket Propellant Exposure Standards in Groundwater</li> <li>Health Effects Standard for TCE/TPH in Groundwater &amp; Soil</li> <li>Remote Hazard Detection</li> <li>Advanced Standards Revision</li> </ul>
<b>RADIATION</b>	
Establish radiation safety guidelines	<ul style="list-style-type: none"> <li>ADT Critical Experiment</li> <li>Ultrawideband Standard</li> <li>Personal RF Dosimeter</li> </ul>
Assess operational impacts	<ul style="list-style-type: none"> <li>ADT Tech Transition</li> <li>Interim Guidelines for Ultra Short Pulse Lasers</li> <li>Combined Effects Modeling</li> </ul>
Promulgate countermeasure criteria	
Determine long-term radiation risks for aircrew	<ul style="list-style-type: none"> <li>Non-Lethal Technologies</li> <li>Advanced Self-Protection Visor</li> </ul>
Exploit radiation effects for national defense	<ul style="list-style-type: none"> <li>NVC/PEM (STANAG)</li> <li>Topographic Effects Modeling</li> <li>Single Event Noise Model</li> <li>ANR Mitigation Tools</li> </ul>
<b>NOISE</b>	
Assess noise and sonic boom impact	<ul style="list-style-type: none"> <li>Military Operating Area Noise Modeling</li> <li>Airbase /Range Monitoring Network</li> <li>Structural Response Model</li> <li>Park/Wilderness Noise Mitigation</li> <li>Wildlife /Domestic Animal Models/studies</li> <li>Sleep Disturbance Model</li> <li>Human Annoyance Studies for Rural Communities</li> </ul>

---

## MAJOR ACCOMPLISHMENTS

---

Transitioned FV-Series laser eye protection (LEP) one year early. This is the first LEP suitable for night time fighter operations. Completed the first flight evaluation of in-band (visible) dye-based LEP. Conducted ground and flight tests which quantified the vulnerability of precision guided munitions to intentional laser situations. Delivered Laser Threat Analysis System (LTAS) to AFIWC/SA on schedule and within budget. Worked with the FAA and FDA to resolve laser illumination incidents affecting military and civilian operations such as laser light shows in the vicinity of airbases and airports.

The Air Force standard "radiofrequency Radiation (RFR) Safety Program" (AFOSH 48-9) was published and promulgated. The NATO STANAG 2345 for radio frequency radiation was unanimously recommended for ratification by the General Medical Working Party. Studies testing the teratological potential of ultrawideband radiation and the possibility of RFR promotion of cancer were completed; no effects were detected. Construction of a new 55,000 square foot Tri-Service Directed Energy Bioeffects Laboratory was begun for occupancy in early FY98.

A 3-D propagation algorithm for ultrawideband radiation was completed and is functional. A mathematical model of electromagnetic and acoustic interaction was completed; this model will structure and facilitate analysis of the health and safety impact of the thermoelastic phenomenon; initial computations indicate that potential damage would be subtle, if present at all. An ocular propagation model was completed and incorporates laser field temporal dispersion through the ocular media, which will aid in the determination of eye safety thresholds for femtosecond pulsed lasers with various carrier frequencies.

Significant accomplishments achieved last year in the Environmental Noise Program include: developed an Animal Noise Monitor that will be used by ACC to study the noise effects on Bighorn Sheep in Idaho; developed a prototype sonic boom monitor that will reduce the current cost of production and deployment by 80%; completed a study on the effect of aircraft noise on Ratites; rewrote the AFM 19-10 as a tri-Service manual for noise environment planning; modified the PCBOOM program to predict the sonic boom footprint from missile launches and verified with measurements at the Channel Islands for a Titan IV launch from Vandenberg AFB; completed a joint study with NASA on peoples' habituation to aircraft induced sleep disturbance; conducted a joint test with the National Park Service on the effects of military aircraft noise on visitors at the White Sands National park; completed a test of the Structural Analysis Tool for ACC at Caliente, NV resulting in new flight restrictions that will significantly reduce the glass breakage in the town from sonic booms; completed a joint measurement program with the Navy on sound propagation over water at NAS Jacksonville.

The Toxicology Division satisfied the customer need for more quantitative and flexible tools for dealing with decisions about selection and use of fire suppressants in AF systems that comply with regulatory standards for ozone depletion and occupational safety. The physiologically-based descriptions of fire suppressant interaction with human systems were used to characterize the human health consequences associated with

deployment of new fire suppressant agents in aircraft engine nacelles and dry bays. This contribution proved to be especially important as it becomes clear that a single fire suppressant replacement will not be capable of replacing the currently fielded Halon 1301.

A new capability to define volatile AF chemical uptake, distribution and elimination in humans for inhalation exposures with durations of less than five minutes was developed. This is extremely important in combat quick turnaround activities and other high risk AF operational activities where rapid, unexpected hazardous material exposures may occur.

Experimental modular artillery charges were evaluated to determine if explosive components were leaching to the outer layers of the newly designed charges and to determine if these components posed any threat to humans handling the explosives.

Studies conducted in support of the Defense Women's Health Research Program demonstrated the utility of using hydra to evaluate chemically induced reproductive toxicity. This work evaluated explosives and propellants including ammonium perchlorate which is a component of solid rocket motors used in weapon and space shuttle systems.

Persian Gulf Veterans Research Program work was completed in which laboratory animals were simultaneously exposed to chemical warfare agent prophylactics, insect repellents, insecticides and physical stressors. The data contributes to the body of knowledge concerned with like physiological responses to mammalian systems under conditions that may exist in contemporary combat conditions.

A major AF base ground water contaminant and the primary driver for clean up costs associated with ground water on and near AF property was re-evaluated for human health risk potential. The project was an intense combination of toxicology laboratory research work and physiologically-based modeling. The work is central to the activity in the Environmental Protection Agency which establishes the remediation standards that are binding on AF installations.

A major effort was initiated that will guide the handling of human health issues relevant to JP-8 use in both US and NATO operations. This effort should greatly reduce the probability of unforeseen JP-8 health and safety problems that could interfere with US air power operations in foreign combat theaters.

---

## CHANGES FROM LAST YEAR

---

The Optical Radiation Division began working a SAF-directed demonstration project of UK dielectric stack laser eye protection (LEP) as a high transmission LEP option for F-15E fighter operations.

The Active Denial Technology Program continues to receive strong support. Two prototype systems have been approved for out year funding by user customers. The systems will be built by Phillips Laboratory, with Armstrong Laboratory providing health and safety analysis.

An extensive study of the basic mechanisms of bioelectric interaction of pulsed, high-peak power microwaves and

ultrawideband radiation is being accomplished through the AFOSR High Power Microwave Initiative and the New World Vistas Program. Electromagnetic fields could couple strongly or highly charged biomolecules and result in electronic polarizations or vibrational responses and measurable biological effects. Findings will be important for both health and safety assessment as well as possible applications of such emissions.

For the Environmental Noise program we successfully completed a phase II SBIR on radar tracking storage system that has led ACC/CEV to purchase these systems for all ACC bases with the PIDP radar. With funding from ACC we will integrate radar data into all our noise modeling. The manager of the Eglin Range has sent us funds to modify our subsonic noise model to model the HERA rockets like we did to PCBOOM for supersonic rocket flights. We have started a joint effort with the Army to update the miniBEAR to collect Blast noise from cannon and tank firings. This work will be supplemented with funds from Eglin to cover a pilot monitoring project at the Eglin Range. We have also started a joint SBIR project with the FAA to develop a multimedia Interactive Sound Information System for use in explaining noise issues to the public.

The Toxicology Division has fully incorporated the business practices and processes to insure user needs are the predominant focus of research activities. We have identified, through the Technology Master Process (TMP), the high priority user needs and formulated research program areas to address these requirements.

---

## MILESTONES

---

During FY98 optical radiation research will develop initial guidelines for aircrew safety to during development, test and evaluation of the Airborne Laser. Issues involved in safe-to-fly and lighting capabilities for dielectric and holographic laser eye protection will be addressed in FY99. By FY00 a concept prototype for laser threat training will be developed. By FY01 the Laser Threat Analysis System (LTAS) will be refined to meet AFIWC requirements by including a dynamic 3-D fly-by-animation capability as well as become high level architecture (HLA) compliant for seamless integration into DoD war gaming.

Tri-Service studies on the ocular damage effects of high power microwaves will be completed in FY98. Based upon modeling, new basic knowledge of bioelectromagnetic interactions, and militarily focused acute, repeated, and chronic exposure studies, RFR health and safety standards will be revised by FY04. For Active Denial Technology, bioeffects for health and safety will be completed in FY99 for a demonstration in FY00.

Algorithms to image simple 3-D biological structures will be completed in FY98. Models for estimating and imaging radiofrequency radiation dosimetry in biological organisms, including the human, will be delivered in FY99. Algorithms and models for ground based environmental health hazard detection, identification, and imaging will be available in FY00, with products for airborne remote use provided in FY01.

By FY98 we will field test the reciprocity method for assessing structural damage from acoustic loading. We will complete development of a sonic boom monitor that will reduce manufacturing and operational costs 20% of the current monitor. We are providing project management and technical expertise for a joint project with ACC to determine the effects of aircraft noise on free-ranging Bighorn Sheep to be completed in FY98.

The toxicology team will develop by the end of FY 98 the ability to predict the blood level of volatile fire suppressants in humans following exposures as short as only 30 seconds. This complex but important capability will allow for the first time a realistic evaluation of the egress and employment procedures that should be used in flight line operations.

The bilateral agreement between the Kingdom of Norway and the US Air Force to evaluate toxic effects of jet fuels has led to the development of a research plan focused to answer real-world exposure and health concerns from both nations.

---

## MAJOR TECHNOLOGY THRUST 5: ENVIRONMENTAL QUALITY

---

### USER NEEDS

---

- **Air Emission Control Technology (All operational MAJCOMs, AFMC).** The USAF, DoD, and other US Agencies need cost effective technologies to control air emissions, e.g., oxides of nitrogen (NO<sub>x</sub>), volatile organic compounds (VOCs), etc., from industrial facilities, boilers, jet engine test facilities, and mobile flight line service equipment.
- **Demilitarization of Solid Rocket Motors (SMC, OO-ALC).** An alternative technology to open burning/open detonation is required to recover components or dispose of solid rocket propellants. Current inventory exceeds 164 million pounds, and is increasing due to Strategic Arms Reduction Treaty (START) requirements, manufacturing waste and shelf-life expenditure.
- **Atmospheric Dispersion Modeling (SMC, NASA).** Improved atmospheric dispersion modeling systems are required at missile launch ranges to more accurately predict toxic hazard corridors. Current models are only 40% to 60% accurate, which may lead to overly conservative predictions and launch delays costing millions of dollars.
- **Modeling, Testing, and Monitoring (All operating MAJCOMs, AFMC, DoD).** Validated, approved technologies and methodologies are required to obtain regulatory approval for the use/implementation of both current and new materials, procedures, and missions such as conversion to JP-8 fuel, detecting dense particles in plastic blast media without using Freon 113 (an ozone depleter), and others.
- **Aircraft De-icing Operations (All operational MAJCOMs).** USAF, DoD, and other US agencies all require an alternative to type I propylene glycol or ethylene glycol aircraft deicers. Both deicers exert high biochemical oxygen demand (BOD) on receiving waters and present high toxicity impacts.
- **Treatment of Chlorinated Solvents in Soil and Groundwater (All USAF).** The USAF, DoD, and other US agencies require validated, approved, cost-effective technologies to clean up soils and groundwater contaminated with chlorinated solvents.
- **Site Characterization and Monitoring (All USAF).** A USAF, DoD, and other US agency soil, groundwater, and atmospheric contamination problem is contaminant source location, identification and delineation, particularly Dense Nonaqueous Phase Liquids. Monitoring costs can range as high as 50% of total remediation costs. Cost effective, regulatory-approved characterization and monitoring technologies are required.
- **Replacements for Chromate Conversion Coating (All operational MAJCOMs, AFMC).** Chromates are targeted by the EPA and USAF for reduced use. This

requires an operationally suitable, cost-effective replacement coating for aircraft parts and surfaces.

- **Plating and Surface Finishing (AFMC).** Cost-effective, operationally suitable alternative metal plating and surface finishing technologies are required to reduce/eliminate the hazardous wastes and health/safety problems associated with conventional electroplating.
- **Wastewater Treatment (All operational MAJCOMs, AFMC).** New treatment technologies are required for removing low levels of emulsified oils from contaminated wastewater from point and non-point sources.

---

### GOALS

---

To meet our users' needs in Environmental Quality, the Armstrong Laboratory will:

- Develop cost-effective technologies to reduce and control nitrogen oxides (in both high- and low-temperature environments), emissions resulting from metal-finishing operations, and various volatile organic compound (VOC) emissions.
- Facilitate the understanding of atmospheric chemistry of volatile materials, validate plume dispersion models, identify low-cost monitoring technologies, and characterize JP-8 and combustion emissions.
- Take the lead to identify the potential environmental problems (air, water, soil transport, treatment, disposal) of novel compounds currently being developed for use in future Air Force systems.
- Develop cost-effective biological processes that destroy fuels, chlorinated solvents, and novel Air Force materials in air, soils or groundwater.
- Develop physical or chemical treatment technologies to reduce or destroy large accumulations of solvents and novel Air Force materials.
- Develop accurate models to track the movement of contaminants in soil and water and predict the interactions with the environment.
- Develop improved technologies to characterize contaminated sites and monitor cleanup/compliance.
- Develop process control systems for pollution prevention applications.
- Develop methods to reduce or eliminate hazardous wastes by modifying large-scale industrial processes and finding new or alternative technologies for solid rocket motor disposal, effluent stream metal removal, oil-water emulsion separation, and complex chemical waste treatment.

## THRUST 5: ENVIRONMENTAL QUALITY

<p><b>SUBTHRUSTS</b></p> <p><b>ENVIRONMENTAL RISK MANAGEMENT TECHNOLOGIES</b></p> <p>Provide technologies to reduce, control, or mitigate environmental risk associated with past, present, and future Air Force operations.</p>	<p><b>ENVIRONMENTAL RISK ASSESSMENT TECHNOLOGIES</b></p> <p>Provide technologies to model and assess the degree of environmental risk from Air Force mission essential operations.</p>
<p>AP Biodegrade</p> <p>Bioremediation of Hydrocarbons</p> <p>Cometabolism</p> <p>Advanced Oxidation Reactor Development</p> <p>Spray Casting Demo</p> <p>Transportable AFFF Treatment System</p> <p>Control for Jet Engine Test Cells (JETCs)</p> <p>Controls for Methylene Chloride Depainting</p> <p>Natural Attenuation Demonstration</p> <p>Space Launch Toxic Model Validation</p>	<p>Bioremediation of Chlorinated Solvents</p> <p>Biotechnology for Industrial Waste Streams</p> <p>HCl 1/1.3 Propellant Disposal</p> <p>Permeable Barriers</p> <p>Nonchromate Conversion Coating</p> <p>NOx Control for Mobile Sources</p> <p>Post Combustion NOx Catalyst for Turbine Engine</p> <p>F &amp; T New AF Compounds</p> <p>Particulate Emission Risk Assessment</p> <p>DNAPL Model</p>

---

## MAJOR ACCOMPLISHMENTS

---

The Environics Directorate investigated the detailed atmospheric chemistry of current and new USAF coatings formulations. The purpose of the research was to more accurately determine the atmospheric impact of coating systems. Volatile organic components in coatings are released into the atmosphere and react to indirectly form ozone and particulate matter, regulated pollutants. The research results highlighted the extreme variability in ground level ozone formation of coating systems. Results will be incorporated into the coating selection process to obtain the coating with minimal atmospheric impact.

AL/EQ has successfully maintained and expanded the use of the Groundwater Remediation Field Laboratory (GRFL) National Test Site at Dover AFB, Delaware. The GRFL is designed for studies and technology demonstrations requiring rigorous mass balance and the controlled release of contaminants into the soil and/or groundwater. The GRFL is the only facility in the US where such research can be performed.

As the DoD lead service for fuel cleanup technologies, AL/EQ has developed various cost-effective biotechnologies which can clean up fuels and certain solvents from contaminated soil and groundwater. Work has begun in extrapolating the bioremediation processes for hydrocarbons to other compounds. An Advanced Applied Technology Demonstration Facility (AATDF) project was initiated (through the Rice Consortium) to investigate cometabolism of solvents and petroleum hydrocarbons. The aerobic process of bioventing, normally applied to petroleum hydrocarbons, is also being applied to such non-petroleum hydrocarbons as acetone and chlorobenzene.

AL/EQ completed the first phase of a program in complex-resistivity geophysics as a detection technique for dense non-aqueous-phase liquids (DNAPL). This hazardous site characterization technology has the potential to significantly improve site assessment methodology. Demonstrations at the GRFL and Hill AFB start in summer 1997.

Through the DARPA TRPs, the Rapid Optical Screening Tool (ROST) has been commercialized and is available world wide. The Environmental Systems Management Analysis and Reporting neTwork (E-SMART) is near commercialization with several demonstrations being planned. The SBIR program has provided several promising technologies which have advanced into the second phase. Nomadics, Inc. is developing a handheld site characterization device. Advanced Fuels Research is developing a miniature gas cell for a field-portable FT-IR spectrometer with application in recirculating paint booths. Dakota Technologies, Inc. is integrating recent advancements in CPT technology into percussion geoprosbes. Simultaneously, Applied Research Associates is continuing development of CPT integrating data mapping and positioning capabilities and extrapolating sonic drilling techniques to the cone penetrometer.

Side-by-side demonstrations of 8 technologies designed to enhance the effectiveness of pump-and-treat systems were initiated at Hill AFB, Utah. These demonstrations will enable us to directly compare the effectiveness of cosolvent flushing,

surfactants, steam injection, and air sparging under similar field conditions. The results will be used to produce guidance documents for applying these processes to remediate contaminated groundwater.

A field study in cooperation with the Tennessee Valley Authority and the American Petroleum Institute is under way to demonstrate the natural attenuation of a residual hydrocarbon source. Fuel has been added and the fuel plume migrated away from the source and stabilized. We are now observing the critical factors of natural attenuation. Results will justify recommending natural attenuation as a remediation alternative for USAF sites with hydrocarbon-contaminated groundwater, resulting in millions of dollars in potential cost savings.

AL/EQ designed and built a model aquifer to investigate the fate and transport DNAPL, the most costly and difficult Air Force contaminant. The model aquifer has provided unequalled ability to experimentally research three-dimensional flow in a completely nonsorptive environment. This effort has improved the understanding of DNAPLs and their behavior in the subsurface. The partition tracer studies for source concentrations provided positive confirmation of mass balances in field studies.

The Modified Sodium Sulfide /Ferrous Sulfate (SS/FS) Metals Treatment Project was completed last year. This project redesigned existing technologies to fit small-scale mobile (skid mounted) systems to reduce waste products of industrial operations. Implementation at applicable USAF bases will reduce waste treatment costs by hundreds of thousands of dollars per year.

The Jet Engine Test Cell (JETC) NO<sub>x</sub> control program passed a significant milestone in its studies of JETC facilities. A modular control system demonstrated greater than 99 percent removal of NO<sub>x</sub> and greater than 90 percent removal of CO and hydrocarbons from 265,000 cfm of exhaust from a "hush house" at McClellan AFB, CA.

The Paint Booth VOC control program also reached a significant milestone in its project life cycle. Designs have been approved for recirculating ventilation in two aircraft painting hangars at ALCs; one of these includes a full-scale biomass device, which will prove the use of biofilters as environmentally friendly VOC control devices.

---

## CHANGES FROM LAST YEAR

---

The Large Rocket Motor Treatment/Disposal program continues; the bioreactor system for ammonium perchlorate and the HydroThermal Oxidation (HTO) system for Class 1.1 propellant are being refined to achieve maximum destruction. The Technical Data Package is being processed.

Research in soil and groundwater treatment continues to shift from fuel contamination, where effective technologies have been fielded, to DNAPLs (principally chlorinated solvents).

---

## MILESTONES

---

The Environics Directorate began operating the one-of-a-kind Groundwater Remediation Field Laboratory (GRFL). The first controlled-release demonstration was completed in FY97. This demonstration is expected to validate cometabolism of chlorinated solvents in the presence of hydrocarbons. A multifaceted approach to DNAPL plume containment consisting of permeable barriers, surfactants, and funnel-and-gate technologies, is forecast to produce cost effective methodologies early in the next decade.

Site characterization and monitoring is focused on noninvasive detection technology for DNAPLs. Ongoing efforts will provide a field demonstration and produce transferable technology by FY99.

The Natural Attenuation Study progressed to the field to provide scientific evidence of the phenomenon of biodegradation. We plan to complete this field demonstration in FY98. This work will allow the Air Force to achieve regulatory acceptance of natural attenuation as a viable alternative to more costly technologies.

Our oil-water emulsion program is just starting. Oil-water emulsions are a large problem for Air Force processes, such as wash rack cleaning and parts degreasing operations. Too much oil in the water can lead to environmental Notices of Violation (NOV), fines, or even work stoppage. We expect this program to have an initial impact on the Air Force by FY98 with numerous additional applications emerging in FY99 and FY00.

During FY96, AL/EQ procured three new reactor systems for on-site research. One system was an HTO research reactor which is being examined to extend this technology to the destruction of other hazardous wastes by FY98. Another was a chemical reactor system to destroy multiphase waste mixtures. This reactor builds upon technology developed by the USAF Airborne Laser Program. It uses singlet oxygen atoms (an excited state) to oxidize waste products (FY02). The third system was a pulsed-corona reactor to investigate destruction of primary and secondary gaseous waste pathways and to investigate novel techniques, including condensed-phase applications (FY99).

AAVP	Advanced Aircrew Vision Protection	IMDSPO	Integrated Maintenance Data System Program Office
ABDA/R	Aircraft Battle Damage Assessment/Repair	IMIS	Integrated Maintenance Information System
ACC	Air Combat Command	IRAD	Independent Research and Development
ACS	Aeromedical Consultation Service	ITS	Intelligent Tutoring System
ADT	Active Denial Technology	JST	Joint Strike Fighter
AETC	Air Education and Training Command	JPATS	Joint Primary Aircraft Training System
AFCEE	Air Force Center for Environmental Excellence	MAJCOM	Major Command
AFOSR	Air Force Office of Scientific Research	MNS	Mission Needs Statement
AFSOC	Air Force Special Operations Command	MPT	Manpower, Personnel, and Training
AFSPACOM	Air Force Space Command	NATO	North Atlantic Treaty Organization
AGARD	Advisory Group for Aerospace Research & Development	NVG	Night Vision Goggles
AGE	Aerospace Ground Support Equipment	PRK	Photorefractive Keratectomy
AIA	Air Intelligence Agency	ORD	Operational Requirements Document
AL	Armstrong Laboratory	R&D	Research and Development
AMC	Air Mobility Command	S&T	Science and Technology
ANC	Active Noise Cancellation	SBIR	Small Business Innovation Research
APT	Advanced Personnel Testing	STANAG	Standardization Agreement
ASAN	Assessment System for Aircraft Noise	STIG	Space Technology
ATAGS	Advanced Technology Anti-G Suit	STOW-E	Interdependency Group
CAD	Computer-Aided Design	TAP	Synthetic Theater of War in Europe
CONUS	Continental United States	TCE	Technology Area Plan
CRDA	Cooperative Research and Development Agreement	TestPAES	Trichloroethylene
DOD	Department of Defense	TMP	Test Planning, Analysis and Evaluation System
DSS	Decision Support System	US	Technology Master Process
EFS	Enhanced Flight Screening	USAF	United States
FATE	Female Acceleration Tolerance Enhancement	VCATS	United States Air Force
FCT	Foreign Comparative Testing	VE	Visually-Coupled Acquisition and Targeting System
G-LOC	G-Induced Loss of Consciousness	VEL	Virtual Environment
HMT/D	Helmet-Mounted Tracker and Display	VT	Visual Electrodiagnostic Laboratory
HP-MSOGS	High Performance-Molecular Sieve Oxygen Generation Sys	VTB	Ventricular Tachycardia
IETM	Interactive Electronic Technical Manual	WAM	Vestibular Test Battery
			Workload Assessment Monitor

---

---

## INDEX

---

---

—A—

Active Denial, 18, 21  
Advanced Aircrew Vision Protection, 26  
Advanced Technology Anti-G Suit, 2, 5, 8, 26  
Aeromedical Standards, 3, 15  
Aerospace Medicine, 2, 3, 5, 15, 20, 21  
Aircrew Training, 3, 12

—B—

Bioremediation, 24

—C—

Cooperative Research and Development Agreements, ii  
Crew Centered Design Technology, 6  
Crew Systems, 2, 3, 6, 8, 9, 17, 18

—D—

Directed Energy, 5, 18, 20, 21

—E—

Ejection Seat Technology, 5, 6, 8, 9  
Electromagnetic Radiation, 20  
Environmental Noise, 18, 20  
Environmental Quality, 2, 3, 5, 24, 25

—F—

Foreign Comparative Testing, 6  
Fundamental Skills Tutor, 5, 12, 14

—G—

G-Protection, 1, 2, 8

—H—

Hazardous Materials, 21  
Helmet Mounted Technology, 4  
Human Resources, 2, 3, 12, 17  
Human Systems Program Office, 2  
Human Systems Technology, ii, 3, 4

—I—

Intelligent Tutoring, 4, 14  
International Research and Development, 4

—J—

Joint Cockpit Office, 4  
Joint Strike Fighter, 8

—L—

Laser Eye Protection, 6, 9, 17, 18, 20, 21  
Logistics Systems Technology, 5

—M—

Manpower, Personnel, and Training, 10

—N—

Night Vision, 6, 8, 15, 17

—O—

Occupational and Environmental Health, 2, 3, 17, 18

—P—

Phillips Laboratory, 5, 20, 21  
Project Reliance, 5, 9, 25

—R—

Rome Laboratory, 5

—S—

Situational Awareness, i, 3, 6  
Small Business Innovation Research, 8  
Surgeon General, 3, 18

—T—

Technology Master Process, 27, 28

Thrusts

    Aerospace Medicine, 15  
    Crew Systems, 2, 6  
    Human Resources, 10  
    Occupational and Environmental Health, 18  
    Environmental Quality, 22  
Toxicology, 1, 5, 18, 20, 21

—U—

US Army, 5, 15  
US Navy, 5, 15

—V—

Vision Standards, 3  
Visually-Coupled Acquisition and Targeting System, 9

—W—

Women in the Cockpit, ii, 15, 17  
Wright Laboratory, 4, 5, 21